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DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

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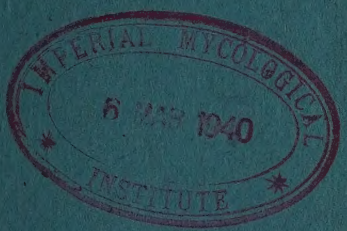

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MECHANICS

BOUNDARY LAYER IN COMPRESSIBLE LIQUID WITH ALLOWANCE FOR RADIATION

By I. A. KIEBEL

(Communicated by N. E. Kochin, Member of the Academy, 3. VIII. 1939)

The lamellar boundary layer, formed in movement of compressible liquid along a plate, has become for some time past the object of investigations of a number of authors.

In particular, it was established [1] that with velocities at infinity considerably higher than that of sound, the temperature of the plate surrounded by a flow rises up tremendously. There is a formula which links up the temperature T_w of the plate (placed in a stream of velocity U and left alone) with the temperature at infinity T_0 and the Barstow number $M = \frac{U}{a_0}$ (a_0 — sound velocity at infinity), namely:

$$T_w = T_0\left(1 + \frac{k-1}{2} M^2\right) \tag{1}$$

(k — ratio of heat capacities).

In establishing this formula, it was not taken into consideration that the plate, left alone, will suffer heat losses through radiation; as long as T_w is small, such losses will be inconsiderable and may be entirely disregarded; however, with large M (and that is, large T_w) the radiation will call forth considerable corrections and the formula (1) will prove to be incorrect. The object of the present paper is to provide a theory of movement of compressible viscous liquid along a plate radiating according to Stephan-Boltzman law. The radiation of the liquid itself is disregarded.

Let a plate be placed along the positive axis X from the origin. Then, the equations of movement in its boundary layer will have the following form:

$$\rho u \frac{\partial u}{\partial x} + \rho v \frac{\partial u}{\partial y} = \frac{\partial}{\partial y}\left(\mu \frac{\partial u}{\partial y}\right) \tag{2}$$

$$\frac{\partial \rho u}{\partial x} + \frac{\partial \rho v}{\partial y} = 0, \tag{3}$$

$$c_p \rho u \frac{\partial T}{\partial x} + c_p \rho v \frac{\partial T}{\partial y} = \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial y}\right) + A\mu \left(\frac{\partial u}{\partial y}\right)^2 \tag{4}$$

wherein u and v are component velocities along the axes X and Y respectively, ρ — density, μ — viscosity coefficient, T — temperature, A — thermal equivalent of work, and λ — heat-conductivity coefficient.

We shall assume that

$$\frac{\mu}{\mu_0}=\left(\frac{T_0}{T}\right)^{0.76} \tag{5}$$

wherein μ_0 and T_0 are viscosity coefficient and temperature at infinity, and that

$$\frac{\rho}{\rho_0}=\frac{T_0}{T} \tag{6}$$

wherein ρ_0 is density at infinity (the pressure is preserved in the boundary layer) and, finally, that the Prandtl's number equals unity so that

$$\lambda=c_p\mu. \tag{7}$$

As the boundary conditions we take

$$\left.\begin{aligned} &u=v=0 && \text{for } y=0,\\ &u=U, \quad T=T_0 && \text{for } y=\infty. \end{aligned}\right\} \tag{8}$$

It must be also expressed that the plate receives the same amount of heat in virtue of the heat-conductivity of the liquid, as it loses through radiation; this we shall set down as follows *:

$$\int_0^L \lambda\frac{\partial T}{\partial y}dx=\int_0^L \sigma\left(T^4-T_0^4\right)dx \qquad \text{for } y=0 \tag{9}$$

wherein L is the length of the plate, and σ—Stephan-Boltzman's constant.

In the sequel the solution of the problem should be considered as approximate, since we shall seek the solution of movement equations for a plate of infinite length, and at the same time use the condition (9) wherein L is finite.

Introducing «stopping temperature» t:

$$t=T+\frac{A}{c_p}\frac{u^2}{2} \tag{10}$$

we transform (4) with the aid of (2) and (5) into:

$$\rho u\frac{\partial t}{\partial x}+\rho v\frac{\partial t}{\partial y}=\frac{\partial}{\partial y}\left(\mu\frac{\partial t}{\partial y}\right). \tag{11}$$

Let us also introduce the current function ψ in order to replace (3) by the equations:

$$\rho u=\rho_0\frac{\partial\psi}{\partial y}, \quad \rho v=-\rho_0\frac{\partial\psi}{\partial x}. \tag{12}$$

We shall now pass to the non-dimensional values x^*, y^*, u^*, v^*, ρ^*, t^* and ψ^*. Let

$$x=Lx^*, \quad y=\frac{L}{\sqrt{R}}y^*, \quad \psi=\frac{LU}{\sqrt{R}}\psi^*,$$

$$u=Uu^*, \quad v=\frac{U}{\sqrt{R}}v^*, \quad \rho=\rho_0\rho^*, \quad t=T_0t^*, \quad \mu=\mu_0\mu^*$$

where R (Reynolds number) is given as

$$R=\frac{\rho_0 UL}{\mu_0}.$$

---

* We assume that the temperature is established at all points of the plate instantaneously. If the plate fails to conduct heat, we should write: $\lambda\frac{\partial T}{\partial y}=\sigma\left(T^4-T_0^4\right)$ for $y=0$. Then the temperature of the plate will be different at different parts. This problem is fully open to solution by our method, but we will not consider it at present.

Finally, we shall go over to the new independent variables ξ and η:

$$\xi = x^*, \qquad \eta = \frac{y^*}{\sqrt{x^*}}$$

and introduce instead of ψ^* the function ζ by the condition

$$\psi^*(\xi, \eta) = \sqrt{\xi}\,\zeta(\xi, \eta).$$

We shall now proceed to seek the solution, in which u^*, t^*, ζ are functions of η only*.

The equations (12) will give us:

$$\rho^* u^* = \frac{d\zeta}{d\eta}. \tag{13}$$

$$\rho^* v^* = -\frac{1}{2\sqrt{\xi}}\left(\zeta - \eta\frac{d\zeta}{d\eta}\right).$$

The equation (2) will take the form

$$\frac{d}{d\eta}\left(\mu^*\frac{du^*}{d\eta}\right) + \frac{\zeta}{2}\frac{du^*}{d\eta} = 0. \tag{14}$$

The equation (11) will give

$$\frac{d}{d\eta}\left(\mu^*\frac{dt^*}{d\eta}\right) + \frac{\zeta}{2}\frac{dt^*}{d\eta} = 0. \tag{15}$$

The equations (14) and (15) enable us to conclude that

$$t^* = a + bu^* \tag{16}$$

wherein a and b are constants.

Using (5), (6) and (10), we are able to write:

$$\rho^* = \frac{1}{a + bu^* - \dfrac{k-1}{2}M^2u^{*2}}; \qquad \mu^* = \left(a + bu^* - \frac{k-1}{2}M^2u^{*2}\right)^{0.76}. \tag{17}$$

Now let us write down the boundary conditions. Instead of (8) we have:

$$u^* = 0, \quad \zeta = 0 \qquad \text{for } \eta = 0, \tag{18}$$

$$u^* = 1, \quad t^* = 1 + \frac{k-1}{2}M^2 \qquad \text{for } \eta = \infty. \tag{19}$$

Taking into account (17), the condition (9) may be easily put into the form

$$\int_0^1 \mu^*\frac{dt^*}{d\eta}\frac{1}{\sqrt{\xi}}\,d\xi = \varepsilon\int_0^1 (t^{*4} - 1)\,d\xi \qquad \text{for } \eta = 0 \tag{20}$$

wherein

$$\varepsilon = \frac{\sigma L T_0^3}{c_p\mu_0\sqrt{R}}. \tag{21}$$

Inasmuch as neither μ^* nor t^* are dependent on ξ, (20) may be integrated and gives if we take into account the expression (17) for μ^* and (18),

$$\frac{dt^*}{d\eta} = \frac{\varepsilon}{2}\frac{t^{*4} - 1}{t^{*0.76}} \qquad \text{for } \eta = 0. \tag{22}$$

---

* If the condition (9) should have to be replaced by the relation $\lambda\dfrac{\partial T}{\partial y} = \sigma(T^4 - T_0^4)$ satisfied at every point of the plate, we should not be able to find the solution as a function of η only. Here we should have to resort to expansion of ξ into a power series in the same manner, as it is done for the boundary layer formed near a curvilinear contour.

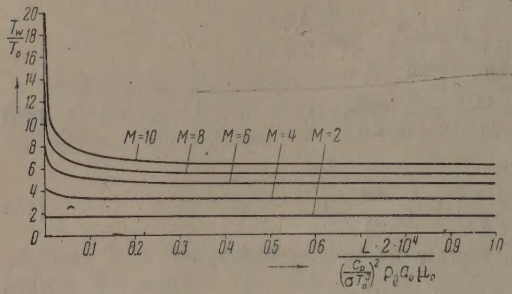
The constants a and b involved in (18) will be connected by the relation:

$$a+b=1+\frac{k-1}{2}M^2 \tag{23}$$

[in consequence of formula (19)] and by the relation:

$$b\left(\frac{du^*}{d\eta}\right)_{\eta=0}=\frac{\varepsilon}{2}\frac{a^4-1}{a^{0.76}} \tag{24}$$

[in consequence of (22)]. If we were to find $\left(\frac{du^*}{d\eta}\right)_{\eta=0}$, we could determine a from (23) and (24), and by (16) establish t^* (and the temperature) on the wall. In order to determine $\left(\frac{du^*}{d\eta}\right)_{\eta=0}$, let us revert to our equations (13) and (14) containing two unknown functions: u^* and ζ. For $u^*=0$, $\eta=0$ there are no singularities in these equations. Let us pass from η to the variable u^* and seek the expression:



$$\mu^*\frac{du^*}{d\eta}=\varphi.$$

We shall obtain

$$\varphi\frac{d\zeta}{du^*}=\mu^*\rho^*u^*=\frac{u^*}{\left(a+bu^*-\frac{k-1}{2}M^2u^{*2}\right)^{0.24}}, \tag{25}$$

$$\frac{d\varphi}{du^*}=-\frac{\zeta}{2}. \tag{26}$$

Expanding φ and ζ into a power series in u^*, we obtain:

$$\varphi=\varphi(0)-\frac{u^{*3}}{12a^{0.24}\varphi(0)}\left\{1-\frac{0.12b}{a}u^*+\frac{0.036}{a^2}\left(2\frac{k-1}{2}M^2a+1.24b^2\right)u^{*2}-\right.$$

$$\left.-0.03333\left[\frac{0.2976}{a^3}\left(6\frac{k-1}{2}M^2a+2.24b^2\right)-\frac{1}{2\varphi^2(0)a^{0.24}}\right]u^{*3}+\ldots\right\}. \tag{27}$$

On the other hand, for larger values of ζ (i. e. for u^* close to unity) we may find an asymptotic expression for φ by simply assuming that

$$\varphi\frac{d\zeta}{du^*}\approx 1;\quad \frac{d\varphi}{du^*}=-\frac{\zeta}{2},$$

i. e.

$$2\varphi\frac{d^2\varphi}{du^{*2}}=-1$$

from which we obtain

$$\frac{d\varphi}{du^*}=-\sqrt{\text{const}-\ln\varphi}=-\frac{\zeta}{2} \tag{28}$$

so that

$$\varphi\approx ce^{-\frac{\zeta^2}{4}} \tag{29}$$

and therefore

$$u^*\approx 1+c\int_{\infty}^{\zeta}e^{-\frac{\zeta^2}{4}}d\zeta\approx 1-2c\frac{e^{-\frac{\zeta^2}{4}}}{\zeta}. \tag{30}$$

By (29) and (30) we have

$$\varphi = \frac{\xi}{2}(1-u^*)$$

and by (28)

$$\varphi = -(1-u^*)\frac{d\varphi}{du^*}.$$

Herein we may now insert the expression for φ, as well as for $\frac{d\varphi}{du^*}$ from (27) (with u^* chosen beforehand); we shall then obtain the equation for determining $\varphi(0)$ in functions of a, b and M. The equation (24) may now be written as

$$b\varphi(0) = \frac{\varepsilon}{2}(a^4-1)$$

and together with (23) will finally enable us to determine a in functions of M and ε.

The results of numerical computations are given in the figure. Here for the abscissa is taken $\frac{L^2 \cdot 10^4}{\left(\frac{c_p}{cT_0^3}\right)^2 \rho_0 a_0 \mu_0}$ and for the ordinate $\frac{T_w}{T_0}$. The values $L=0$ correspond to the formula (1); with $L \to \infty$ for all M will be $\frac{T_w}{T_0} \to 1$. For large M, the temperatures sharply decrease with an increase of L. Thus, if $\rho_0 = 1.3 \cdot 10^{-3}$, $\mu_0 = 1.7 \cdot 10^4$, $T_0 = 2.73 \cdot 10^2$, $\frac{c}{c_p} = 5.833 \cdot 10^{-12}$ (all in CGS), then for $M=10$ we shall obtain for $L=10^2$ cm; $\frac{T_w}{T_0} \approx 5.2$ and not 21, as we should have according to formula (1).

After the values of a and $\varphi(0)$ are established, it is fairly easy to construct the distribution of velocities and temperatures by means of the following formula:

$$c_f = \frac{8}{3}\frac{\varphi(0)}{\sqrt{R}}.$$

We are also able without any difficulty to compute the resistance coefficient c_f.

Leningrad State University.

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13. VIII. 1939.

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MATHEMATICAL PHYSICS

PROPAGATION OF WAVES IN TWO DIMENSIONS

By J. A. MINDLIN

(Communicated by S. L. Sobolev, Member of the Academy, 10. IX. 1939)

The subject of the present work consists in a solution of problems relating to the propagation of vibrations in two-dimensional space. The cases are considered viz.: when the problem has been reduced to a single wave equation or when it is considered as a system of two wave equations, as is the case in the theory of elasticity, the boundary for the given medium being a circle (external and internal problems). We evolve here the methods suggested by H. Lamb.

In his work H. Lamb(1) has found for the case of radial vibrations in two-dimensional space a solution analogous to the one given by d'Alambaire for a one-dimensional wave equation. A similar form of solution was already proposed some time ago by T. Levi-Civita (2).

The integral of the two-dimensional wave equation

$$\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial y^2}=\frac{1}{a^2}\frac{\partial^2 U}{\partial t^2} \tag{1}$$

for the case of radial vibrations given by Levi-Civita and Lamb has the following aspect:

$$U=\int_0^\infty \left[f\left(t-\frac{r}{a}\cosh\xi\right)+F\left(t+\frac{r}{a}\cosh\xi\right)\right]d\xi$$

and is, as will be readily seen, in analogy with the solution given by d'Alambaire. In the present work we construct a formula which is analogous to d'Alambaire's solution for the case of arbitrary vibrations, and we also discuss the questions of the propagation of elastic disturbances when there exists a boundary in the form of a circle.

The integral of wave equation (1) which represents a generalization of Lamb and Levi-Civita's solution has the form:

$$U=\int_0^\infty \left[A_n^{(1)}\left(t-\frac{r}{a}\cosh\xi\right)+A_n^{(2)}\left(t+\frac{r}{a}\cosh\xi\right)\right]\cosh n\xi d\xi\cdot e^{in\vartheta} \tag{2}$$

where n is a positive integer or zero.

Let us prove that the first term of equality (2)

$$U_n^{(1)}=\int_0^\infty A_n^{(1)}\left(t-\frac{r}{a}\cosh\xi\right)\cosh n\xi\, d\xi\cdot e^{in\vartheta} \tag{3}$$

represents a spreading wave really satisfying equation (1). It is, of course, assumed that function $A_n^{(1)}(\mu)$ is such as to make converge the integral of formula (3). A sufficient (yet not essential) condition for this is

$$\lim_{\mu \to -\infty} \mu^{n+\varepsilon} A_n^{(1)}(\mu) = 0 \tag{4}$$

where ε is any positive quantity. Substituting expression (3) into wave equation (1) expressed in polar co-ordinates, we have:

$$a^2\left(\frac{\partial^2 U}{\partial r^2} + \frac{1}{r}\frac{\partial U}{\partial r} + \frac{1}{r^2}\frac{\partial^2 U}{\partial \theta^2}\right) - \frac{\partial^2 U}{\partial t^2} =$$

$$= \int_0^\infty \left\{ \frac{a^2}{r^2}\frac{\partial^2}{\partial \xi^2}\left[A_n^{(1)}\left(t - \frac{r}{a}\cosh\xi\right)\right] - \frac{a^2 n^2}{r^2} A_n^{(1)}\left(t - \frac{r}{a}\cosh\xi\right)\right\} \cosh n\xi \, d\xi \cdot e^{in\theta} =$$

$$= -\left\{ \frac{a}{r}\left[\cosh n\xi \sinh \xi \, A_n^{(1)\prime}\left(t - \frac{r}{a}\cosh\xi\right)\right]_{\xi=0}^{\xi=\infty} + \right.$$

$$\left. + \frac{a^2}{r^2}\left[\sinh n\xi \, A_n^{(1)}\left(t - \frac{r}{a}\cosh\xi\right)\right]_{\xi=0}^{\xi=\infty} \right\} e^{in\theta} = 0.$$

Condition (4) will evidently be satisfied if $A_n^{(1)}(\mu)$ becomes zero with negative values of μ exceeding a certain limit. An analogous proof may, as well, be applied to the second term of equality (7) on condition that

$$\lim_{\mu \to \infty} \mu^{n+\varepsilon} A_n^{(2)}(\mu) = 0. \tag{4'}$$

Let us now prove that any solution $U(r, \theta, t)$ of wave equation (1) becoming zero at infinity may be represented in the following way:

$$U(r, \theta, t) = \sum_{n=0}^{\infty} \int_0^\infty [\Phi_n^{(1)}(r\cosh\xi, t)\cos n\theta + \Phi_n^{(2)}(r\cosh\xi, t)\sin n\theta]\cosh n\xi \, d\xi \tag{5}$$

functions $\Phi_n^i(r\cosh\xi, t) = \Phi_n^i(X, t)$ satisfying the equation for the vibration of a string:

$$\frac{\partial^2 \Phi_n^i(X, t)}{\partial X^2} = \frac{1}{a^2}\frac{\partial^2 \Phi_n^i(X, t)}{\partial t^2}. \tag{6}$$

The character of the transformation of function $U(r, \theta, t)$ at infinity will be made clear hereafter.

For the purpose of proving our contention let us expand function $U(r, \theta, t)$ into Fourrier's series and then we obtain

$$U(r, \theta, t) = \sum_{n=0}^{\infty} a_n^{(1)}(r, t)\cos n\theta + a_n^{(2)}(r, t)\sin n\theta. \tag{7}$$

Substituting into formula (5) for $U(r, \theta, t)$ its value determined by expression (7) and making the coefficients of $\cos n\theta$ and $\sin n\theta$ equal in both parts of the equation, we obtain for the determination of $\Phi_n^{(1)}$ and $\Phi_n^{(2)}$ two integral equations independent of one another:

$$a_n^i(r, t) = \int_0^\infty \Phi_n^{(i)}(r\cosh\xi, t)\cosh n\xi \, d\xi \qquad \begin{pmatrix} i = 1, 2 \\ n = 0, 1, 2 \ldots \end{pmatrix} \tag{8}$$

For the case of $n=0$ an analogous equation was solved by Schlömilch ([3]) in 1857. We carried out ([4]) the solution of an equation analogous to (8) in 1934. For the convergence of integral (8) it will be sufficient that the sought function $\Phi_n^i(\mu, t)$ should satisfy the condition:

$$\lim_{\mu\to\infty} \mu^{n+\varepsilon}\, \Phi_n^i(\mu, t) = 0$$

where ε is any positive quantity.

Let function $a_n(r, t)$ be continuous along with its first derivative with respect to r with $0 \leqslant r < \infty$ and let it satisfy condition

$$\lim_{r\to\infty} r^{n+\varepsilon}\, a_n^i(r, t) = 0; \qquad \varepsilon > 0 \tag{9}$$

then integral equation (8) will have a continuous solution in the stated interval, and if $\frac{\partial^2 a_n(r, t)}{\partial r^2}$ is continuous, then $\frac{\partial \Phi_n^i(r, t)}{\partial r}$ will exist and be continuous too, such a solution holding, however, true only on the condition that

$$\lim_{r\to\infty} r^{n+\varepsilon}\, \Phi_n^{(i)}(r, t) = 0. \tag{10}$$

Function $\Phi_n^{(i)}(r, t)$ should be determined by the following formula with n being a positive integer:

$$\Phi_n^{(i)}(r, t) = -\frac{2}{\pi} \int_0^\infty \Big[n\, a_n^{(i)}(r \cosh \xi, t) + \\ + r \cosh \xi \, \frac{\partial\, a_n^{(i)}(r \cosh \xi,\, t)}{\partial\, (r \cosh \xi)} \Big] T_{n-1}(\operatorname{sech} \xi)\, d\xi \tag{11}$$

where $T_n(\mu) = \cos(n \text{ arc } \cos \mu)$ is Tchebyshev's polynome.

For the case $n=0$ equation (8) was solved by Schlömlich. It has the following form:

$$\Phi_0^{(i)}(r, t) = -\frac{2}{\pi} r \int_0^\infty \frac{\partial\, a_0^{(i)}\ (r \cosh \xi,\, t)}{\partial\, (r \cosh \xi)}\, d\xi.$$

Finding from both parts of expression (11) partial derivatives of the 2nd order with respect to r and t, we become convinced that function $\Phi_n^{(i)}(r, t)$ determinable by formula (11) actually satisfies the equation for the vibration of a string, provided function

$$a_n^{(i)}(r, t)\,[\cos n\theta + i \sin n\theta]$$

satisfies the equation for the vibration of a membrane.

From formula (11) we see that the way, in which functions $\Phi_n^{(i)}(r, t)$ become reduced to zero, is the same as that of the given function $a_n^{(i)}(r, t)$. Thus, we have proved that any solution of equation (11) determinable by equality (7), whose Fourrier's coefficients satisfy condition (9), may be represented as a uniformly convergent series in the following form:

$$U(r, \theta, t) = \sum_{n=0}^{\infty} \Big\{ \int_0^\infty [A_n^{(1)}(at - r \cosh \xi) + \\ + A_n^{(2)}(at + r \cosh \xi)] \cosh n\xi\, d\xi \cos n\theta \Big\} + \\ + \sum_{n=1}^{\infty} \Big\{ \int_0^\infty [B_n^{(1)}(at - r \cosh \xi) + B_n^{(2)}(at + r \cosh \xi)] \cosh n\xi\, d\xi \sin n\theta \Big\}. \tag{12}$$

Assuming the existence of a solution for Cauchy's problem in the case of equation (1), we obtain on the basis of the above results an easy solution of this problem.

In fact, reverting to formula (12), we see that we have to determine the arbitrary functions so that

$$\left.\begin{aligned} U\Big|_{t=0} &= U_0(r,\theta) = \sum_{n=0}^{\infty} a_n^{(1)}(r)\cos n\theta + b_n^{(1)}(r)\sin n\theta. \\ \frac{\partial U}{\partial t}\Big|_{t=0} &= U_0'(r,\theta) = \sum_{n=0}^{\infty} a_n^{(2)}(r)\cos n\theta + b_n^{(2)}(r)\sin n\theta \end{aligned}\right\} \tag{13}$$

functions $a_n^{(1)}(r)$ and $b_n^{(1)}(r)$ satisfying condition (9) and functions $a_n^{(2)}(r)$ and $b_n^{(2)}(r)$—condition (9), in which n is replaced by $n+1$. In order to satisfy the initial conditions of (13) we should have

$$\left.\begin{aligned} a_n^{(1)}(r) &= \int_0^{\infty} [A_n^{(1)}(-r\cosh\xi) + A_n^{(2)}(r\cosh\xi\, d\xi)]\cosh n\xi\, d\xi \\ \frac{1}{a}a_n^{(2)}(r) &= \int_0^{\infty} [A_n^{(1)\prime}(-r\cosh\xi) + A_n^{(2)\prime}(r\cosh\xi)]\cosh n\xi\, d\xi. \end{aligned}\right\} \tag{14}$$

Analogous integral equations are also obtained for the sought functions $B_n^{(i)}$ $(i=1,2)$. On the basis of formula (11) the solution of integral equations (14) for $n \geqslant 1$ has the form

$$A_n^{(1)}(-r) + A_n^{(2)}(r) = -\frac{2}{\pi}\int_0^{\infty} [n\, a_n^{(1)}(r\cosh\xi) + r\cosh\xi\, a_n^{(1)\prime}(r\cosh\xi)]\, T_{n-1}(\operatorname{sech}\xi)\, d\xi \tag{15}$$

and

$$A_n^{(1)\prime}(-r) + A_n^{(2)\prime}(r) = -\frac{2}{\pi a}\int_0^{\infty} [n\, a_n^{(2)}(r\cosh\xi) + r\cosh\xi\, a_n^{(2)\prime}(r\cosh\xi)\, T_{n-1}(\operatorname{sech}\xi)\, d\xi. \tag{16}$$

For $n=0$, we have

$$A_0^{(1)}(-r) + A_0^{(2)}(r) = -\frac{2r}{\pi}\int_0^{\infty} a_0^{(1)\prime}(r\cosh\xi)\, d\xi \tag{17}$$

and

$$A_0^{(1)\prime}(-r) + A_0^{(2)\prime}(r) = -\frac{2r}{\pi a}\int_0^{\infty} a_0^{(2)\prime}(r\cosh\xi)\, d\xi. \tag{18}$$

Equality (16) can be replaced by

$$A_n^{(1)}(-r) - A_n^{(2)}(r) = \frac{2}{\pi a}\int_{\infty}^{r} d\mu \int_0^{\infty} [n\, a_n^{(2)}(\mu\cosh\xi) + \mu\cosh\xi\, a_n^{(2)\prime}(\mu\cosh\xi)]\, T_{n-1}(\operatorname{sech}\xi)\, d\xi. \tag{19}$$

Similarly, equality (18) can be replaced by an equivalent one, but for the sake of brevity we do not write it out here. The solution of Cauchy's problem is now fully available, since formulae (15) and (19) determine $A_n^{(1)}$

for the negative and $A_n^{(2)}$ for the positive values of the argument, while the determination of $A_n^{(1)}$ for the positive values of the argument is given by

$$A_n^{(1)}(at) + A_n^{(2)}(at) = 0 \qquad (20)$$

which represents the condition of «continuity» at the origin of co-ordinates (5).

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MATHEMATICAL PHYSICS

SOLUTION OF CAUCHY-DIRICHLET'S EXTERNAL PROBLEM FOR A WAVE EQUATION IN THE CASE OF A CIRCLE

By J. A. MINDLIN

(Communicated by S. L. Sobolev, Member of the Academy, 10. IX. 1939)

The subject of the present work is the solution of problems on the propagation of vibrations connected with a single wave equation:

$$\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial y^2}=\frac{1}{a^2}\frac{\partial^2 U}{\partial t^2} \tag{1}$$

a circle serving as the boundary of the medium (external problem). We give a solution of Cauchy-Dirichlet's problem for the exteriority of a circle of radius 1 on the presumption of the existence of a solution for this problem. In terms of mathematics this problem is expressed as the problem of finding the integral of equation (1) for $r>1$, satisfying the so-called initial and boundary conditions

$$\left.\begin{aligned} U\Big|_{t=0} &= U_0(r,\theta)=\sum_{n=0}^{\infty} a_n^{(1)}(r)\cos n\theta+b_n^{(1)}(r)\sin n\theta \\ \frac{\partial U}{\partial t}\Big|_{t=0} &= U_0'(r,\theta)=\sum_{n=0}^{\infty} a_n^{(2)}(r)\cos n\theta+b_n^{(2)}(r)\sin n\theta \end{aligned}\right\} \tag{2}$$

$$U\Big|_{r=1}=\varphi(\theta,t)=\sum_{n=0}^{\infty} p_n(t)\cos n\theta+q_n(t)\sin n\theta. \tag{3}$$

We assume that coefficients $a_n^{(i)}(r)$ and $b_n^{(i)}(r)$ of the expansion into a Fourrier series of the functions determining the initial conditions will satisfy a condition of the following form:

$$\lim_{r\to\infty} r^{n+\varepsilon}a_n^{(1)}(r)=0,\ \lim_{r\to\infty} r^{n+1+\varepsilon}a_n^{(2)}(r)=0. \tag{4}$$

Conditions (4) will, evidently, be satisfied if functions $a_n^{(i)}(r)$ and $b_n^{(i)}(r)$ become zero with such values of r which exceed a certain limit.

For the solution of the problem we resort to a representation of the solution of equation (1) by an integral as given in the preceding paper, which is analogous to d'Alambaire's integral. We have:

$$\begin{aligned} U=\sum_{n=0}^{\infty}\int_0^{\infty}\{&[A_n^{(1)}(at-r\cosh\xi)+A_n^{(2)}(at+r\cosh\xi)]\cos n\theta+ \\ &+[B_n^{(1)}(at-r\cosh\xi)-B_n^{(2)}(at+r\cosh\xi)]\sin n\theta\}\cosh n\xi\, d\xi. \end{aligned} \tag{5}$$

Satisfying the initial conditions (2), we should have

$$\left.\begin{aligned} a_n^{(1)}(r) &= \int_0^\infty [A_n^{(1)}(-r\cosh\xi) + A_n^{(2)}(r\cosh\xi)]\cosh n\xi\, d\xi \\ \frac{1}{a}a_n^{(2)}(r) &= \int_0^\infty [A_n^{(1)\prime}(-r\cosh\xi) + A_n^{(2)\prime}(r\cosh\xi)]\cosh n\xi\, d\xi. \end{aligned}\right\} \quad (6)$$

We obtain analogous integral equations also for unknown functions $B_n^{(i)}$ $(i=1,2)$. Integral equations (6) presenting generalized Schlömlich's integral equations whose solution was given in the foregoing paper permit of finding function $A_n^{(1)}$ when the argument varies within $(-\infty, -1)$ and function $A_n^{(2)}$ for values of the argument lying within $(1, \infty)$. We have for $n \geqslant 1$:

$$A_n^{(1)}(-r) + A_n^{(2)}(r) = \frac{2}{\pi}\int_0^\infty [n\, a_n^{(1)}(r\cosh\xi) + r\cosh\xi\, a_n^{(1)\prime}(r\cosh\xi)]\, T_{n-1}(\operatorname{sech}\xi)\, d\xi \quad (7)$$

and

$$A_n^{(1)\prime}(-r) + A_n^{(2)\prime}(r) = -\frac{2}{\pi a}\int_0^\infty [n\, a_n^{(2)}(r\cosh\xi) + r\cosh\xi\, a_n^{(2)\prime}(r\cosh\xi)]\, T_{n-1}(\operatorname{sech}\xi)\, d\xi. \quad (8)$$

For $n=0$ we have

$$A_0^{(1)}(-r) + A_0^{(2)}(r) = -\frac{2r}{\pi}\int_0^\infty a_0^{(1)\prime}(r\cosh\xi)\, d\xi \quad (9)$$

and

$$A_0^{(1)\prime}(-r) + A_0^{(2)\prime}(r) = -\frac{2r}{\pi a}\int_0^\infty a_0^{(2)\prime}(r\cosh\xi)\, d\xi \quad (10)$$

the assumption being made that functions $a_n^{(i)}(r)$ become zero with $r < 1$. Equality (8) can be replaced by

$$A_n^{(1)}(-r) - A_n^{(2)}(r) = \frac{2}{\pi a}\int_\infty^r d\mu \int_0^\infty [n\, a_n^{(2)}(\mu\cosh\xi) + \mu\cosh\xi\, a_n^{(2)\prime}(\mu\cosh\xi)]\, T_{n-1}(\operatorname{sech}\xi)\, d\xi. \quad (11)$$

Similarly, equality (10) may be replaced by an equivalent one, but for the sake of brevity we do not write it out here.

Equalities (7) and (11) determine unknown functions $A_n^{(1)}(-r)$ and $A_n^{(2)}(r)$ for r varying within $(1, \infty)$. Functions $B_n^{(i)}$ are determined in a similar manner.

In order to determine $A_n^{(1)}$ and $B_n^{(1)}$ for other values of the argument we shall satisfy the boundary conditions; thereby we shall have

$$p_n(t) = \int_0^\infty A_n^{(1)}(at - \cosh\xi)\cosh n\xi\, d\xi + \int_0^\infty A_n^{(2)}(at + \cosh\xi)\cosh n\xi\, d\xi \quad (12)$$

$$q_n(t) = \int_0^\infty B_n^{(1)}(at - \cosh\xi)\cosh n\xi\, d\xi + \int_0^\infty B_n^{(2)}(at + \cosh\xi)\cosh n\xi\, d\xi. \quad (13)$$

Let us now attend to the finding of the sought function $A_n^{(1)}$ from integral equation (12) for values of the argument varying within the interval $(-1, \infty)$. Let us introduce into the first integral of equation (12) a new variable of integration $z = at - \operatorname{cosh}\xi$, and into the second integral $\varsigma = at + \operatorname{cosh}\xi$, whereupon we obtain:

$$p_n(t) = \int_{-\infty}^{at-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}} + \int_{at+1}^{\infty} \frac{A_n^{(2)}(z)\, T_n(z-at)\, dz}{\sqrt{(z-at)^2-1}}. \qquad (14)$$

The second term of the right-hand side of integral equation (14) represents a known function for any $t \geqslant 0$. Now let us split up into two the first term of equation (14):

$$\left.\begin{aligned} \int_{-\infty}^{at-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}} = \int_{-\infty}^{-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}} + \\ + \int_{-1}^{at-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}}. \end{aligned}\right\} \qquad (15)$$

The first term of the right-hand side of equality (15) represents a known function. For the sake of brevity let us denote

$$\left.\begin{aligned} \int_{-\infty}^{-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}} = h_n^{(1)}(t) \\ \int_{at+1}^{\infty} \frac{A_n^{(2)}(z)\, T_n(z-at)\, dz}{\sqrt{(z-at)^2-1}} = h_n^{(2)}(t). \end{aligned}\right\} \qquad (16)$$

With the notations adopted by us integral equation (14) will assume the following aspect:

$$p_n(t) - h_n^{(1)}(t) - h_n^{(2)}(t) = \int_{-1}^{at-1} \frac{A_n^{(1)}(z)\, T_n(at-z)\, dz}{\sqrt{(at-z)^2-1}}. \qquad (17)$$

Substituting a single letter, x, for the upper limit of the integral, i. e. assuming $at - 1 = x$, we have

$$p_n\left(\frac{x+1}{a}\right) - h_n^{(1)}\left(\frac{x+1}{a}\right) - h_n^{(2)}\left(\frac{x+1}{a}\right) = \int_{-1}^{x} \frac{A_n^{(1)}(y)\, T_n(x-y+1)\, dy}{\sqrt{(x-y+1)^2-1}} \qquad (18)$$

whereby with $x = -1$ the left-hand side of equality (18) turns zero, since the boundary conditions are consistent with the initial ones. Equations of the type of (18) were studied by Sonin [1] as early as in 1884, this being previous to the appearance of the general theory of integral equations.

From the general theory of integral equations of the first kind of Volterra's type [2] it follows that equation (18) has a single solution. We find the solution of equation (18) in the usual way. It has the form:

$$A_n^{(1)}(y) = \int_{-1}^{y} H_n(y-z) \frac{d}{dz}\left[p_n\left(\frac{z+1}{a}\right) - h_n^{(1)}\left(\frac{z+1}{a}\right) - h_n^{(2)}\left(\frac{z+1}{a}\right) \right] dz. \qquad (19)$$

Resolvent $H_n(z)$ is determined by an expression of the following form:

$$H_n(z) = \frac{1}{2\pi i} \int_{\delta-i\infty}^{\delta+i\infty} \frac{e^{sz}\, e^{-s}}{s K_n(s)}\, ds, \qquad (20)$$

where $K_n(s)$ is a Basset-Macdonald function well-known from the theory of Bessel functions, while δ is a sufficiently large positive number. The solution of Cauchy-Dirichlet problem for the exteriority of a circle of radius 1 is now available in full, since formulae (7), (11) and (19) determine function $A_n^{(1)}$ for values of the argument varying within interval $(-\infty, +\infty)$, as well as function $A_n^{(2)}$ for values of the argument lying within interval $(1, \infty)$. Functions $B_n^{(i)}(\mu)$ are found in a similar way. Yet, as can be seen from formula (5) which provides a solution of equation (1), the arguments of the functions sought vary just within the aforesaid interval.

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MATHEMATICAL PHYSICS

PROPAGATION OF ELASTIC WAVES IN TWO DIMENSIONS

By J. A. MINDLIN

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In the present work a solution is given (on the assumption that such solution exists) to the problem of the vibration of a portion of a plane lying outside a circumference with radius R under arbitrary initial conditions and with any given projections U_r, U_θ of the displacement vector on the circumference. The expression of the components of the displacement vector in terms of potentials is known to have for a plane problem in the theory of elasticity the following form (in polar co-ordinates):

$$U_r = \frac{\partial \varphi}{\partial r} + \frac{1}{r}\frac{\partial \psi}{\partial \theta}, \qquad U_\theta = \frac{1}{r}\frac{\partial \varphi}{\partial \theta} - \frac{\partial \psi}{\partial r} \tag{1}$$

where functions φ and ψ satisfy equations

$$\left.\begin{aligned} \Delta\varphi &= \frac{1}{a^2}\frac{\partial^2 \varphi}{\partial t^2}, \qquad \Delta\psi = \frac{1}{b^2}\frac{\partial^2 \psi}{\partial t^2} \\ a &= \sqrt{\frac{\lambda + 2\mu}{\rho}}, \qquad b = \sqrt{\frac{\mu}{\rho}} \end{aligned}\right\}. \tag{2}$$

We denote the density of the medium by ρ and Lamé's elastic constants by λ and μ.

In terms of mathematics the stated problem appears as a problem of finding the integrals of system of equations (2) for $r > R$ satisfying the so-called initial and boundary conditions:

$$U_r \Big|_{t=0} = \sum_{n=0}^{\infty} a_n^{(1)}(r)\cos n\theta + b_n^{(1)}(r)\sin n\theta$$

$$U_\theta \Big|_{t=0} = \sum_{n=0}^{\infty} a_n^{(2)}(r)\cos n\theta + b_n^{(2)}(r)\sin n\theta$$

$$\frac{\partial U_r}{\partial t}\Big|_{t=0} = \sum_{n=0}^{\infty} a_n^{(3)}(r)\cos n\theta + b_n^{(3)}(r)\sin n\theta$$

$$\frac{\partial U_\theta}{\partial t}\Big|_{t=0} = \sum_{n=0}^{\infty} a_n^{(4)}(r)\cos n\theta + b_n^{(4)}(r)\sin n\theta$$

$$U_R\Big|_{r=R} = \sum_{n=0}^{\infty} p_n^{(1)}(t)\cos n\theta + q_n^{(1)}(t)\sin n\theta$$

$$U_R\Big|_{r=R} = \sum_{n=0}^{\infty} p_n^{(2)}(t)\cos n\theta + q_n^{(2)}(t)\sin n\theta.$$

We assume that coefficients $a_n^{(i)}(r)$ and $b_n^{(i)}(r)$ of the expansion into series of Fourrier's functions determining the initial state satisfy the condition of the following form:

$$\lim_{r\to\infty} r^{n+1+\varepsilon} a_n^{(i)}(r)=0, \quad (i=1,2) \qquad (3)$$

$$\lim_{r\to\infty} r^{n+2+\varepsilon} a_n^{(i)}(r)=0, \quad (i=3,4).$$

Conditions (3) will, evidently, be satisfied provided functions $a_n^{(i)}(r)$ and $b_n^{(i)}(r)$ become zero with the values of r exceeding a certain limit. In order to find the sought functions φ and ψ we shall represent the solutions of equations (2) by an integral analogous to d'Alambaire's integral. We have:

$$\varphi=\sum_{n=0}^{\infty}\left\{\int_0^{\infty}[A_n^{(1)}(at-r\cosh\xi)+A_n^{(2)}(at+r\cosh\xi)]\cosh n\xi\, d\xi\cos n\vartheta\right\}+$$

$$+\sum_{n=1}^{\infty}\left\{\int_0^{\infty}[B_n^{(1)}(at-r\cosh\xi)+B_n^{(2)}(at+r\cosh\xi)]\cosh n\xi\, d\xi\sin n\vartheta\right\} \qquad (4)$$

$$\psi=\sum_{n=0}^{\infty}\left\{\int_0^{\infty}[C_n^{(1)}(bt-r\cosh\xi)+C_n^{(2)}(bt+r\cosh\xi)]\cosh n\xi\, d\xi\cos n\vartheta\right\}+$$

$$+\sum_{n=1}^{\infty}\left\{\int_0^{\infty}[D_n^{(1)}(bt-r\cosh\xi)+D_n^{(2)}(bt+r\cosh\xi)]\cosh n\xi\, d\xi\sin n\vartheta\right\}. \qquad (5)$$

Satisfying initial conditions, we obtain after some simple transformations a system of integral equations for the determination of functions $A_n^{(i)}$ and $D_n^{(i)}$ $(i=1,2)$. Introducing the notations:

$$A_n^{(1)}(-\mu)+A_n^{(2)}(\mu)=A^{(1,n)}(\mu) \qquad (6)$$

$$-A_n^{(1)}(-\mu)+A_n^{(2)}(\mu)=A^{(2,n)}(\mu) \qquad (7)$$

and similar notations for other functions, we should have:

$$\left.\begin{aligned} a_n^{(1)}(r)+b_n^{(2)}(r)&=\int_0^{\infty}[A^{(1,n)'}(r\cosh\xi)+D^{(1,n)'}(r\cosh\xi)]\cosh(n-1)\xi d\xi \\ a_n^{(1)}(r)-b_n^{(2)}(r)&=\int_0^{\infty}[A^{(1,n)'}(r\cosh\xi)-D^{(1,n)'}(r\cosh\xi)]\cosh(n+1)\xi d\xi, \end{aligned}\right\} \qquad (8)$$

we obtain analogous integral equations also for $A^{(2,n)''}$, $D^{(2,n)''}$, as well as for derivatives $B^{(i,n)}$, $C^{(i,n)}$.

Integral equations (8), as well as the integral equations for $A^{(2,n)''}$ and $D^{(2,n)''}$ being virtually the generalized integral equations of Schlömlich, whose solution was given by us in our preceding papers, permit of finding functions $A_n^{(1)}$, $B_n^{(1)}$, $C_n^{(1)}$, $D_n^{(1)}$ upon variation of argument within the interval of $(-\infty, -R)$ and also functions $A_n^{(2)}$, $B_n^{(2)}$, $C_n^{(2)}$, $D_n^{(2)}$ for the values of the argument lying within the interval (R, ∞). For determination of functions $A_n^{(1)}$, $B_n^{(1)}$, $C_n^{(1)}$, $D_n^{(1)}$ for values of the argument varying within the interval $(-R, \infty)$ we shall satisfy boundary conditions. We have:

$$p_n^{(1)}(t)+q_n^{(2)}(t)=\int_{-\infty}^{at-R}\frac{-A_n^{(1)'}(z)T_{n+1}\left(\frac{at-z}{R}\right)dz}{\sqrt{(z-at)^2-R^2}}+$$

$$+\int_{at+R}^{\infty}\frac{A_n^{(2)'}(z)\,T_{n+1}\left(\frac{z-at}{R}\right)dz}{\sqrt{(z-at)^2-R^2}}+\int_{-\infty}^{bt-R}\frac{D_n^{(1)'}(z)\,T_{n+1}\left(\frac{bt-z}{R}\right)dz}{\sqrt{(z-bt)^2-R^2}}-$$

$$-\int_{bt+R}^{\infty}\frac{D_n^{(2)'}(z)\,T_{n+1}\left(\frac{z-bt}{R}\right)dz}{\sqrt{(z-bt)^2-R^2}}. \qquad (9)$$

$$p_n^{(1)}(t)-q_n^{(2)}(t)=\int_{-\infty}^{at-R}\frac{-A_n^{(1)'}(z)\,T_{n-1}\left(\frac{at-z}{R}\right)dz}{\sqrt{(z-at)^2-R^2}}+$$

$$+\int_{at-R}^{\infty}\frac{A_n^{(2)'}(z)\,T_{n-1}\left(\frac{z-at}{R}\right)dz}{\sqrt{(z-at)^2-R^2}}+\int_{-\infty}^{bt-R}\frac{-D_n^{(1)'}(z)\,T_{n-1}\left(\frac{bt-z}{R}\right)dz}{\sqrt{(z-bt)^2-R^2}}+$$

$$+\int_{bt+R}^{\infty}\frac{D_n^{(2)'}(z)\,T_{n-1}\left(\frac{z-bt}{R}\right)dz}{\sqrt{(z-bt)^2-R^2}}. \qquad (10)$$

We obtain analogous relations also for functions $B_n^{(i)}$ and $C_n^{(i)}$.

The terms of the right-hand sides of equalities (9) and (10) comprising functions $A_n^{(2)}$ and $D_n^{(2)}$ represent known functions for any $t\geqslant 0$. We now break up into two the other terms on the right-hand side of the equalities in the following manner:

$$\int_{-\infty}^{at-R}\{\}\,dz=\int_{-\infty}^{-R}\{\}\,dz+\int_{-R}^{at-R}\{\}\,dz \qquad (11)$$

$$\int_{-\infty}^{bt-R}\{\}\,dz=\int_{-\infty}^{bt-R}\{\}\,dz+\int_{-R}^{bt-R}\{\}\,dz. \qquad (12)$$

The first terms of the right-hand sides of (11) and (12) constitute known functions.

Transferring the known terms from the right-hand sides of equations (9) and (10) to the left-hand sides, we arrive at the system of integral equations of the first kind of Volterra's type for functions $A_n^{(1)}$ and $D_n^{(1)}$ with a determinant different from zero, whose terms are nuclei of integral equations. The integral equations here obtained afford the possibility of determining functions $A_n^{(1)}$ and $D_n^{(1)}$ in the final form within interval $(-R,\ \infty)$. We now have a complete solution of the problems since functions $A_n^{(1)}$, $B_n^{(1)}$, $C_n^{(1)}$, $D_n^{(1)}$ are determined for the values of the argument varying within interval $(-\infty,\ +\infty)$ and functions $A_n^{(2)}$, $B_n^{(2)}$, $C_n^{(2)}$, $D_n^{(2)}$ are determined for the values of the argument lying within interval $(R,\ \infty)$.

Yet, as can be seen from formulae (4) and (5) giving a solution to the system of equations (2), the arguments of the sought functions vary precisely within the stated interval. The problem with given tensions may be solved in a similar way.

In the next communication we intend to give a proof of the representation of the solution of three-dimensional wave equations in the form:

$$U(x,y,z,t)=\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(ix\sinh u\cosh v - y\sinh u\sinh v + z\cosh u + at, u, v)\cdot$$

$$\cdot du\,dv + \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} F(ix\sinh u\cosh v - y\sinh u\sinh v + z\cosh u - at, u, v)\,du\,dv \quad (13)$$

and we shall show the application of integral (13) to the solution of problems on the propagation of elastic vibrations within three-dimensional space.

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BIOCHEMISTRY

SOME PECULIARITIES OF THE ENZYME SYSTEM OF APPLE LEAVES AND THEIR PHYSIOLOGICAL IMPORTANCE

By B. RUBIN and N. SISSAKIAN*

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The first tentative investigations conducted by us on apple leaves already showed (1), that the principles established previously for a number of annual and biannual cultures (2,3,4,5) hold good for this subject. It appeared in particular, that the activity of the peroxidase in the late (winter) varieties is much higher than that of the early (summer) varieties. In studying the activity of the invertase in the live tissue of the same groups after Kursanov's method (6), it was established that the late varieties have a considerably wider ratio synthesis/hydrolysis, than have the early varieties.

This work is devoted to the description of the results of experiments performed by us in order to verify and to develop further previous observations.

I. Activity of Peroxidase and Earliness of the Fruit. Many studies of peroxidase in 1939 for many varieties made it possible fully to confirm the conclusions of the experiments of 1938. If activity of the enzyme fluctuated from 8 to 25 units in the late variety group, it was only 1—5 units in the early (summer) varieties. The differences between these groups were even more pronounced in the action of peroxidase in the midrib of the leaf, the petiole and the growth sprouts.

Besides, this year we met with some (quite few) exceptions from this rule which again did not appear matters of chance and repeated previous observations. One of these exceptions is, for instance, the Papirovka—one of the earliest varieties—which during 2 years, invariably in many tens of cases, showed peroxidase action peculiar to the late varieties. In the winter variety group the most constant exception was Calvile-anis whose leaves had a very low peroxidase activity, peculiar to the summer variety.

In connexion with the principle mentioned above, there arises a question—to what extent is the earliness of the variety related to the peroxidase action in its tissues; have we here to do with the actual physiological explanation of the characters mentioned, or only with a kind of parallelism, a correlation of properties internally unrelated.

The data which we obtained on peroxidase in accordance with the varieties made us assume that the activity of this enzyme is related to the ageing

* With the assistance of T. Ivanova.

of the leaf, and the nature of this process, its intensity in the early varieties should be different from that of the late varieties. In attempting to reach an experimental solution of this problem, we studied the peroxidase in leaves of various ages and the changes in activeness of this enzyme in connexion with the so-called nodosity of the leaf.

In Table 1 and Fig. 1 we give some of the results obtained by us in this connexion (the leaf tests were taken from undergrown sprouts or from branches of the first node of the two-year-old seedlings).

Table 1

Activity of Peroxidase in Leaves of Different Varieties of Apple-Trees in Relation to their Situation on the Branches

Leaf No.	Slavyanka (late variety)	Papirovka (early variety)	Golden Kitaika (early variety)
1st	25.0	9.3	2.1
2nd	16.7	11.0	1.1
3rd	10.1	6.7	1.1
5th	16.5	1.8	0.0
7th	12.4	0.0	0.0
10th	8.5	1.0	0.0
13th	10.0	0.0	0.0

Both figures in Table 1 and the curves in the figure show convincingly, that the increasing of duration of the leaf's life, its ageing is accompanied by decrease in activeness of peroxidase in the apple-tree, which is common to all the varieties—the early ones, as well as the late ones. The velocity of this process, however, is considerably greater in the early than in the late varieties. As a result, about the fifth leaf on the branch of the seedling of an early variety has practically no active peroxidase. From data of the table we also see the dual nature of the Papirovka variety, the first three leaves of which have a high activity of peroxidase which is characteristic of this variety and distinguishes it sharply from the group of early varieties to which it belongs. This property is, however, displayed by the Papirovka in the nature of the decrease in peroxidase activity when the leaves age. We see that the curve of the Papirovka corresponds fully to that of the Golden Kitaika (a typical early variety), as a result of which, beginning with the fifth leaf, the activity of the enzyme is close to zero.

From all of this we may conclude that the differences in the activity of the peroxidase in the leaves of the early and late varieties are due to different rates of the process of physiological ageing of the leaves.

A leaf of the early variety young in the sense of age is considerably older from the physiological point of view, than a leaf of exactly the same age taken from the late variety. A leaf of the early variety at the moment when it has not yet finished development, already bears the features of the aged organism (or at any rate ageing) in comparison with the same kind of a leaf of the late variety. Causes of such inactivation of the peroxidase, as the leaf ages, have not been studied at all as yet. Assuming that we have to do with the accumulation of specific inhibitors of this enzyme (of the tannine type) in the leaf tissues, we are now studying the activity of polyphenoloxidase on the same material. The results of this study will be published later.

That the relation between the degree of earliness of the apple variety and the activity of the peroxidase in its leaves is not accidental, is confirmed

by the results which we obtained in a whole series of experiments on the influence of the «mentor».

Attaching great importance to the environmental factors with regard to their effect upon the course of development and the final quality of the hybrid seedling, I. V. Michurin applied (7) a special method which he called the «mentor» method, as one of the most important way of action upon phasically young organisms in order to further their development in the desired direction. This method is based upon the relation between the scion and the stock and consists in grafting the cuttings or buds of an organism in the stage of formation (phasically young, according to Michurin) upon the branches of a phasically old organism (of a definite variety).

It seemed interesting to determine whether insertion of a hybrid seedling in the top of a phasically old tree affects the activity of its peroxidase, and whether the shift observed thereby is related to the nature of the seedling.

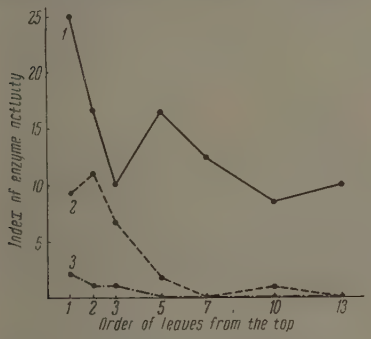

Fig. 1. —— Slavyanka (late var.), — — — Papirovka (early var.), —·—· Golden Kitaika (early var.).

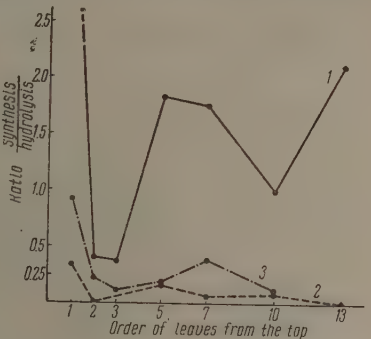

Fig. 2. Same symbols, as in Fig. 1.

Thanks to the kind permission of I. I. Isaiev of the Michurin Central Researsch Institute, we were able in studying this problem to make use of material from experiments on this subject conducted there. Table 2 gives some of the data obtained in our experiments.

In most cases we observed pronounced shifts in the action of the peroxidase which originated in the leaves of the seedling under the influence of the mentor, in whose top it was grafted, and these changes took place in a direction depending on the nature of the mentor. When late varieties of apple-trees were used as mentor, the activity of the peroxidase in the seedling increased, but early varieties made the peroxidase less active.

We will not dwell upon the nature of the relation between the scion and stock and fully confirm I. V. Michurin's statements on this subject, but we consider it necessary to note only that the material given in Table 2 testifies even more convincingly to the existence of a really intimate bond between the peroxidase index and the degree of earliness of the apple-tree variety.

The figures show that in acting upon the nature of the seedling, in increasing its lateness (grafting into the top of a late variety) we simultaneously increase the activity of peroxidase of the scion and vice versa. Such a relation between the characters may exist only if they depend upon one another internally from a physiological point of view.

II. Action of Invertase in Apple-Tree Varieties. On this problem we shall give only a few figures which characterize the changes in the relation between the synthesizing and hydrolyzing action

Table 2

Changes in the Activity of the Peroxidase in the Leaves of a Hybrid Seedling under the Action of Mentor

Hybrid combination and activeness of the peroxidase in the leaves of a mother seedling	Kind of mentor	Peroxidase in the leaves of a seedling grafted into the top of the mentor
Slavyanka×Pepin Shafran	Reinette Bergamot (winter variety).	3.8
Ditto	Belle-fleur Kitaika (fall variety)	2.3
Grey Anis×Pepin Shafran	Reinette Bergamot (winter variety)	2.0
Ditto	Belle-fleur Kitaika (fall variety)	1.2
Brown Stripe×Welsey	Slavyanka (winter variety)	2.8
Ditto	Golden Kitaika (summer variety)	0.9
Brown×Slavyanka № 50 2.1	Slavyanka (winter variety)	3.4
Ditto	Belle-fleur Kitaika (fall variety)	1.7
Same combination № 80] 1.5	Slavyanka (winter variety)	2.9
Ditto	Belle-fleur Kitaika (fall variety)	1.5
Brown×Papirovka 1.5	Antonovka (late variety)	8.5
Grushovka×Belle-fleur Kitaika 0.0	» » »	5.3

Table 3

Action of Invertase in the Live Tissue of the Leaves of Different Varieties of Apple-Trees in Relation to their Situation on the Branches (mg sugar per 10 g leaves per 1 hour)

No. of leaves	Slavyanka (winter variety)			Golden Kitaika (summer variety)			Papirovka (summer variety)		
	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II
1st	5.3	0.0	—	9.2	10.0	0.92	3.1	9.1	0.34
2nd	6.7	16.0	0.40	4.4	20.4	0.22	0.0	31.5	0.0
3nd	3.7	10.0	0.37	3.4	25.6	0.13	—	—	—
5th	19.6	10.7	1.83	6.0	32.0	0.19	3.1	20.5	0.15
7th	13.8	7.9	1.75	13.3	34.7	0.38	2.4	40.1	0.06
10th	8.7	8.7	1.00	4.4	36.7	0.12	2.0	26.2	0.08
13th	13.3	6.0	2.21	—	—	—	0.0	31.6	0.0

of invertase in leaves of various ages. The purpose of the experiments was described above in detail.

The curves of the ratio synthesis/hydrolysis for the same varieties according to height of the leaves on the stem are given in Fig. 2.

Besides the general relation between the late and early varieties with regard to the action of the invertase which we already know, these data show that the differences between the ratios synthesis/hydrolysis of the varieties

are determined chiefly by differences in the hydrolytic action of the enzyme which is far greater in the early varieties than in the late varieties, while the differences in the magnitude of the synthesizing action are much less. The general tendency of the early varieties is a pronounced increase in the hydrolytic action of the enzyme as the leaves grow old. This magnitude is much more stable for the late variety. The general activity of invertase (total of hydrolysis and synthesis) which is considerably higher in the early varieties in comparison with the late ones, also attracts attention.

Thus, we again have indications as to the variable character of the physiological changes, accompanying the ageing of tissues in the early and late varieties, which is manifested mainly in the rate of the processes which is very small in leaves of the late variety.

The invertase of the latter is expressed here as a considerably more conservative system, less elastic and variable and less active on the whole in comparison with the invertase in the leaves of early varieties.

The actual importance of these peculiarities of invertase, considered in connexion with the earliness of variety, is the subject of a further investigation.

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BIOCHEMISTRY

INFLUENCE OF SALTS ON ENZYMIC ACTIVITY IN A LIVING CELL UNDER LOW TEMPERATURE CONDITIONS

By N. SISSAKIAN and B. RUBIN

(Communicated by A. N. Bach, Member of the Academy, 16. VIII. 1939)

In the preceding communication (1) the authors were able to show that the enzymic activity in a living cell undergoes considerable changes when under the influence of low temperature. It was established, moreover, that in the leaves of cold-resistant apple varieties the synthetic and the hydrolytic action of enzymes are in a fairly stable equilibrium at low temperature. This is not, however, the case with the leaves of the apple-varieties not resistant to cold which usually lose this capacity for synthesis when the temperature drops to 0°C or lower. The reason which the authors put forward to account for the variable response of the enzymic apparatus to cold was that at low temperatures destruction of vegetative cells is due to an irreversible shift of the enzyme equilibrium in the direction of hydrolysis. However, a number of essential problems bearing upon the inner nature of the frost-resistance of vegetative organisms remained unexplored.

In physiological investigations of cold-resistance considerable space was devoted to ascertaining the nature of the so-called chemical protection of plants against freezing. Thus, a number of authors (2,3,4,5 and others) have shown that the solutions of various salts as well as sugars and a number of other chemical compounds are endowed with the power of protecting plants against freezing. To the opinion of some of them the specific significance of these compounds consists in the fact that they prevent the coagulation of proteins.

It was essential, therefore, to ascertain exactly what is the influence of these compounds on the enzymic system of a living cell when the latter is exposed to the action of low temperature. In view of this the authors studied the temperature curve of the action of invertase and protease in apple leaves, to which some frost-protective substance was artificially added. This work will be a description of the results of experiments performed by the authors on this subject.

The material of study were the apple leaves of the Borsdorf Kitaika and Candile Kitaika varieties, of which the former is considerably more frost-resistant than the latter, and also strawberry leaves. The apple leaves were taken from two-year-old seedlings in the nursery of the I. V. Michurin Central Genetic Laboratory. The strawberry leaves were taken from the experimental base of the I. V. Michurin Fruit Research Institute in the city of Michurinsk.

A study of the temperature curve (Figs. 1 and 2) of the action of invertase which was done after Kursanov's method ([6]) showed that in the cold-resistant Borsdorf Kitaika variety equilibrium between the synthetic and the hydrolytic action of the invertase stays at quite a high level even at temperatures below zero. The behaviour of the Candile Kitaika variety which is not resistantto frost is diametrically opposite in this respect. In full accord with the data of previous experiments ([1]), we state again that at temperatures below zero invertase in this variety loses its synthesizing action, while its hydrolytic activity increases pronouncedly. As the temperature decreases further, the hydrolytic activity of the enzyme also decreasesin both varieties.

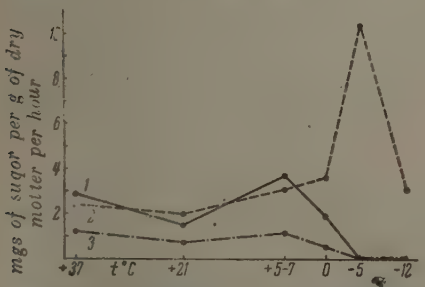

Fig. 1. —— synthesis, — — — hydrolysis, — · — · ratio synthesis/hydrolysis.

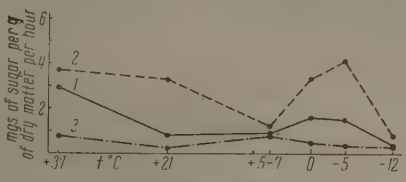

Fig. 2. Same symbols, as in Fig. 1.

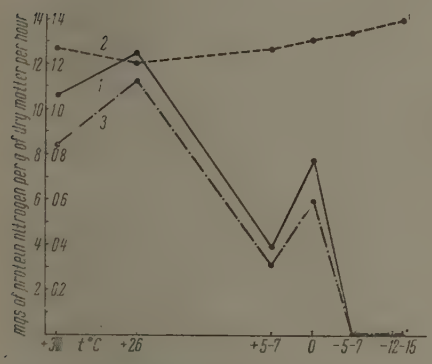

Fig. 3. Same symbols, as in Fig. 1.

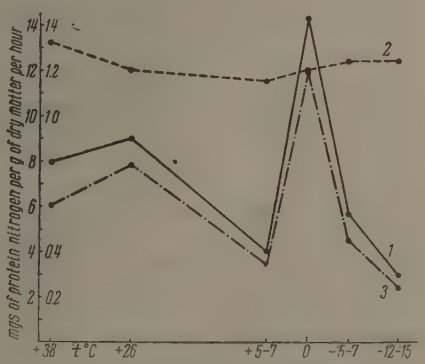

Fig. 4. Same symbols, as in Fig. 1.

It is important to mention the fact that the Candile Kitaika variety gives a second maximum in its synthesizing activity at a fairly high temperature (+7°C); while the Borsdorf Kitaika variety has its second maximum in the low temperature zone (±0°—5°C).

The hydrolytic activity maximum of invertase for both varieties is at —5°C. These data show that in determining the cold-resistance of plants it is very important to preserve a determinable equilibrium between the building-up and the breaking-down action of the enzymes.

Investigation of the synthesizing [after Kursanov's method ([7])] and the hydrolyzing ([8]) capacities of proteases gave results close in nature (Figs. 3 and 4). At temperatures below zero the synthesizing capacity of proteases disappears entirely in the Candile Kitaika variety, while in the Borsdorf Kitaika variety this aetivity retains a considerable value even at—12—15°C. The synthesis maximum of proteases is at +26°C for Candile Kitaika and at ±0°C for Borsdorf Kitaika.

Thus, the leaves of varieties of apple-trees, differing in cold-resistance, are affected by low temperatures quite differently, so far as the orientation of the enzymic activity toward synthesis or hydrolysis is concerned. The action of low temperatures on the non-resistant variety results in the enzymes displaying one-sided hydrolytic activity. In the cold-resistant variety the enzymes retain their synthesizing action at a considerable height at quite low temperatures. Therefore, cold-resistance is closely connected with, and possibly even determined by the capacity of the plant to keep the equilibrium between the synthetic and hydrolytic action of enzymes at a definite level, close to the initial value and peculiar to the variety concerned.

The protective actions of salts and glucose were studied by infiltering the latter into the leaves of the test plants 24 hours before cooling was begun. The first experiments in which 0.3 *n* of KCl solution were infiltered into the leaves of two varieties of apple-trees, gave the following results.

Table 1

t in °C	Action of invertase in mg saccharose on 1 g dry substance per hour						Variety
	with H_2O			with KCl			
	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II	
± 0	0.9	3.2	0.28	1.6	1.9	0.84	Candile Kitaika (non cold-resistant)
— 5—7	0.1	4.2	0.02	4.2	4.5	0.93	
—12—5	0.0	2.8	—	1.8	2.4	0.75	
± 0	6.7	7.0	0.96	6.1	6.0	1.02	Borsdorf Kitaika (cold-resistant)
— 5—7	0.9	3.1	0.29	3.2	3.4	0.94	
—12—15	0.2	4.0	0.05	2.9	3.5	0.83	

The introduction of KCl solution greatly changes the action of invertase. The KCl solution not only helps to preserve the synthesizing capacity of the ferment, but also stimulates the fermentative action of the living cell. The non-cold-resistant variety Candile Kitaika, which entirely loses its synthesizing activity within the interval—5—12°C, greatly increases its synthesis when KCl solution is introduced. The Borsdorf Kitaika variety gives an analogous phenomenon. The results of repeated tests of the influence of KCl, NaCl and $CaCl_2$ on strawberry leaves are given in Table 2.

Table 2

t in °C	Action of invertase in mg saccharose on 1 g dry substance per hour											
	with H_2O			with KCl			with NaCl			with $CaCl_2$		
	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II	synthesis I	hydrolysis II	I/II
± 0	1.1	—	—	0.9	3.7	0.24	1.3	5.3	0.25	0.0	0.4	—
—2—3	4.5	0.7	6.43	6.5	5.9	1.10	0.0	9.6	—	0.0	5.9	—
—5—7	1.7	2.6	0.65	4.7	12.1	0.39	0.0	6.3	—	0.0	0.7	—

These tests showed that only the introduction of KCl solution into living tissue stimulate the synthesizing capacity of invertase. NaCl and especially $CaCl_2$ solutions greatly depress and even stop the synthesizing action of invertase. KCl preserves not only the synthesizing activity of invertase, but also that of proteases.

Table 3

t in °C	Synthesizing capacity of proteases in mg of protein nitrogen on 1 g dry substance per hour	
	With H_2O	With KCl
± 0	6.06	4.54
− 5	0.0	7.22
−12	0.0	4.82

The figures in Table 3 show clearly that in leaves infiltered with water the synthesizing activity of proteases disappear completely at—5—12°C. If, however, KCl is introduced, the leaves retain their activity at a fairly high level within the same temperature range. Thus, in this experiment KCl solution quite definitely displays its protective effect on the synthesizing action of the enzymes of living plant cells. These observations resemble the experiments of other investigators ([9],[10]) who were successful in observing a higher level of synthesizing processes in plants, by introducing KCl into the living tissue and by setting up a definite regime of potassium supply to the plants during the vegetation period. The results obtained by us with glucose were somewhat unexpected.

It should be noted that a preliminary introduction of a glucose solution (0.3 n) both in studying the action of invertase and in studying the synthesizing capacity of proteases gave the following results. In spite of the conceptions existing in literature, the introduction of a glucose solution (0.3 n) into the leaf tissues resulted in the syntheses of invertase and the proteases greatly depressed. At the same time the hydrolytic capacities of the enzymes increased.

Since further experiments are in progress, we shall not draw any final conclusions at this writing. Nevertheless, the observations which we have made emphasize, to our opinion, the necessity of reviewing a number of statements pertaining to the problem of the factors which control the action of enzymes in the living cell, as well as to the problem of the most important factors in determining the resistance of tissue to cold.

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STRATIGRAPHY

KHOPER BEDS IN ORSK-KHALILOVO REGION

By G. I. TEODOROVICH

(Communicated by A. A. Borissiak, Member of the Academy, 10. IX. 1939)

In the summer of 1936 while taking part in the Orsk-Khalilovo expedition of the Academy of Sciences of the USSR, the author detected some peculiar deposits referred by him to the Khoper beds. Their location is at a certain point of the Orsk-Khalilovo region—the Guberli river basin, along the Salyr ravine, 2 km upstream of the Novo-Kievsky village. Stratigraphically they are above the beds of the *Belemnitella americana* Mort., a zone which has been characterized with certainty. In the summer of 1937 the author visited this place again. The uppermost portion of the *Belemnitella lanceolata* Schloth. zone lie bare here, represented by ununiformly coloured (brownish-yellow and light greenish-grey) glauconite-bearing marls with relatively abundant *Bel. lanceolata* Schloth. and single *Bel.* aff. *americana* Mort*. Furthermore are the deposits of the *Bel. americana* Mort. zone (~2 m thick), consisting of more or less calcareous clays of a light greenish-grey colour or a grey with a greenish tinge, and including *Bel. americana* Mort. and occasionally abundant pelecypods, exposed here too, and so are also the Khoper beds. The latter in the ascending order are represented by:

Pg_1^{Chp1}: 1) Polished gravel, interspersed with glauconite-quartz alevrite sand; thickness 0.10 m.

2) Sand of the same type with dispersed gravel; thickness 0.30—0. 35 m.

3) A greenish-grey argillaceous glauconite rock with separate gravel particles; thickness 0.10 m.

4) A light-greyish phosphate-bearing (P_2O_5=6—8.1%) argillaceous glauconite rock of varying thickness (from 0.10 to 0.0 m) in the upper portion of a yellow or rusty-yellow colour.

$Pg_1^{Chp2(?)}$: 5) A band (2—5 cm) of polished gravel and coarse-grained sand with fine gravel (silicates, quartz, etc.) and glauconite grains; the interjacent mass is argillaceous.

6) A light greyish gaize-like glauconite-bearing silicite with sponge spicules; irregular more solid grey patches are observed enriched with sponge-spicules (spongiolitic silicite); visible thickness of layer—1.00 m.

Ten steps to the north (in another small exposure) small lens-like areas were detected within this rock which were lighter in colour and showed sometimes an uneven and sometimes a conchoidal fracture. Those conchoidal fractures gave a positive reaction on P_2O_5 and on microscopical examination were found to be a phosphate-argillaceous-glauconitic rock. The presence of these areas may probably be taken to mean that layers 5 and 6 of the exposure belong to the upper half of the Khoper beds.

Conclusions. 1. The above deposits designated by the author as Pg_1^{Chp} may be correlated with the so-called Khoper beds from their stratigraphical position and lithological composition.

* Identified by A. L. Yanshin, checked by N. S. Shatsky.

2. The Khoper beds have not been found anywhere else to lie stratigraphically above the deposits of the *Bel. americana* Mort. zone, i. e. clearly above the Upper Maestrichtian. This occurs only in the exposure described by the author. Now it is possidle to draw a parallel (at least in the Orsk-Khalilovo region) between the Khoper beds and the deposits of the Danian, while formerly we could only surmise the existence of such correlation ([6],[2],[3]).

3. The author regards the above-described Khoper beds of the Orsk-Khalilovo region as marine sediments of the Danian from relatively shallow waters. The marine origin of the Khoper beds of this region is evidenced by: a) the abundance in them of fresh glauconite grains which have not been redeposited; b) the presence of rocks in which glauconite locally takes part not only in the composition of the cemented grains, but also in the composition of the cement itself; c) individual findings of separate foraminifers (*Textulariidae*) in certain silicites and phosphate-bearing rocks Pg_1^{Chp}.

4. The reduced P_2O_5 content in our phosphate-bearing rocks as compared to the typical high-grade Khoper and Volsk ([5]) phosphorites, the absence of iron ores and the abundance of glauconite which has not been redeposited, should be explained by the fact that the Khoper deposits described have been formed at a somewhat greater distance from the shore-line than the typical Khoper phosphorites and the Khoper iron ores ([1]). This opinion is fully confirmed by findings of pebbles of white high-grade phosphorites (32% P_2O_5) in the Kain-Kabak river basin ([2])—northward from our exposure, i. e. nearer to the shore-line of the Danian sea. These pebbles, found by P. L. Bezrukov and A. L. Yanshin at the base of the Paleocene, present, according to these authors, «remains of eroded phosphorite beds of the Khoper type» ([2]).

Inasmuch, however, as the section of the lower phosphate-bearing portion of the Khoper beds ([6]) is known to be incongruous, it is to be expected that in the course of further works in the Orsk-Khalilovo region bands and lenses of Pg_1^{Chp} deposits may be encountered with a higher P_2O_5 content.

5. The Khoper deposits described are chiefly of a chemical origin, which refers first of all to their phosphate content.

6. The Khoper beds of the Khoper river basin may be subdivided schematically into three parts (in ascending order): a) sand, b) brown ironstones, non-nodular, phosphorites, etc.; c) gaizes ([6]). In the above section all three members of this scheme are present; of these the lower and middle ones are designated as Pg_1^{Chp1} and the upper one as $Pg_1^{Chp2(?)}$.

7. In the case under investigation the Khoper beds are eroded to a certain extent and overlie the deposits of the *Belemnitella americana* Mort. zone. This circumstance suggests the idea that pre-Khoper or pre-Danian upheavals took place in this region (old Laramie phase of orogenesis).

Thus, the author's data are consistent with the observations made by P. L. Bezrukov. The considerations put forward in his paper on the Danian stage ([2]) are fully supported by the author who also refers the Khoper beds and the Danian deposits in general to the lowermost part of the Paleogene.

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GENETICS

BREED DETERMINED DIFFERENCES IN BLOOD INDICES OF FOWLS

By O. N. KITAEVA

(Communicated by N. I. Vavilov, Member of the Academy, 9. VIII. 1939)

Interior indices of domestic cattle and poultry, especially their blood picture, have long attracted the attention of various investigators. The knowledge of the status of physiological indices and the law of their variation is likely to contribute to a better understanding of the animal constitution.

We have investigated the fowls kept in the vivarium of the Institute of Genetics of the Academy of Sciences of the USSR. A total of 121 specimens were investigated, comprising 38 Langshans, 46 Brown Leghorns, 27 Bentams, 10 Yurlovskie golosistye. The investigation was run at 3 different dates: in May 1937, in June and December 1938. Haemoglobin estimation was made after Sahli; erythrocyte counts, in the Thomas Zeiss chamber; the size of erythrocytes was determined on dry non-stained smears, and blood alkalinity—after Nevodov.

The results of our investigation on the blood composition of fowls, without reference to the season, in which the analyses were made, are summarized in Table 1. Literary data on seasonal variations of the blood indices of birds are conflicting. Some authors ([1], [5]) report the content of haemoglobin and the number of erythrocytes to increase in autumn and winter, while others ([2]) have found them to be higher in spring.

Fowls investigated by us were kept in winter in warm pens, where they were not exposed to the influence of the cold weather. Besides, comparison of analyses made at different seasons has not revealed any essential differences within one and the same breed, hence their results are united in Table 1. By Götze's method slightly modified for chickens we have taken new measurements of the surface and volume of erythrocytes, haemoglobin content and haemoglobin surface of one erythrocyte and in 100 cm^3 of blood (Table 2).

a) Age Variation. Our investigation was concerned with the following age groups: born in 1938, aged 3—7 months; 1937, aged 12 to 20 months, and adults over 2 years old. Besides, 6 one-day chicks were investigated, which showed the following values (Table 3):

Table 1

Race, Age and Sex Related Differences in Blood Indices of Fowls

	n	Haemoglobin after Sahli	Alkalinity in mg %	Erythrocyte number in millions	Length of erytrocytes in μ	Width of erythrocytes in μ
Adults						
Langshans						
Cocks	4	71.8	500	3.49	11.35±0.056	6.63±0.04
Hens	16	55.7±1.38	414	3.13±0.12	11.16±0.16	6.33±0.09
Brown Leghorns						
Cocks	1	68.5	440	3.95	11.4 ±0.051	7.02±0.037
Hens	5	53.5	360	2.62	11.2 ±0.048	6.92±0.039
Benthams						
Cocks	8	63.82±2.63	—	3.28±0.22	10.71±0.266	6.707±0.82
Hens	4	49.55	—	2.45	10.16±0.064	6.63 ±0.051
Yurlovskie golosistye						
Cocks	—	—	—	—	—	—
Hens	—	—	—	—	—	—
Born in 1937, aged 12—20 months						
Langshans						
Cocks	3	62.5	—	3.12	11.54±0.051	6.83±0.037
Hens	9	57.23±0.91	—	3.102±0.087	11.38±0.086	6.53±0.11
Brown Leghorns						
Cocks	7	70.5 ±1.91	506	3.34 ±0.087	11.39±0.074	7.2 ±0.088
Hens	16	47.97±1.94	—	2.507±0.09	11.29±0.089	6.83±0.051
Benthams						
Cocks	6	69.31±1.87	—	3.34 ±0.184	11.4 ±0.158	6.92 ±0.065
Hens	8	50.13±1.47	—	2.549±0.11	11.16±0.139	6.606±0.061
Yurlovskie golosistye						
Cocks	—	—	—	—	—	—
Hens	—	—	—	—	—	—
Born in 1938, aged 3—7 months						
Langshans						
Cocks	8	52.65±0.996	410±26.8	2.74±0.12	11.81±0.096	6.8 ±0.057
Hens	6	51. 8±2.08	406±12.6	2.7 ±0.18	11.49±0.14	6.81±0.078
Brown Leghorns						
Cocks	10	54.13±2.45	380±18	2.83±0.14	11.45±0.085	7.04±0.06
Hens	7	46.95±1.82	400	2.49±0.16	11.07±0.254	6.79±0.11
Benthams						
Cocks	3	66.7	—	3.55	10.65±0.052	6.87±0.041
Hens	4	51.57	—	2.72	10.67±0.049	6.74±0.039
Yurlovskie golosistye						
Cocks	1	71	—	3.49	11.61±0.051	6.52±0.036
Hens	4	57.84	—	3.05	11.17±0.045	6.79±0.033

Table 2

Blood Picture of Adult Fowls

Sex and breed	n	O_1	V_1	O_{100}	V_{100}	$\frac{O}{V}$	Hgl_{100}	Hgl_1	D	L_1	L_{100}
Langshans cocks . .	4	154.0	137.5	53.1	47.4	1.12	12.41	35.0	0.254	391	139.1
» hens . . .	16	147.6	129.4	46.1	40.5	1.14	9.64	30.8	0.238	351	109.7
Brown Leghorns cocks	1	162.5	150.4	64.1	60.0	1.07	11.85	30.0	0.199	323	127
» » hens.	5	158.1	145.3	41.4	38.0	1.09	9.25	35.3	0.244	385	100.02
Benthams cocks . . .	8	145.2	129.0	47.6	42.3	1.13	11.02	33.6	0.260	378	124
» hens . . .	4	136.8	119.4	33.5	29.3	1.14	8.58	35.0	0.293	400.8	98

Note: n—number of fowls under investigation; O_1—surface of one erythrocyte in microns; V_1—volume of one erythrocyte in microns; O_{100}—total surface in m^2 of erythrocytes in 100 cm^3 of blood; V_{100}—total volume (in cm^3) of erythrocytes in 100 cm^3 of blood; $\frac{O}{V}$ — specific surface; Hgl_{100}—amount of haemoglobin in 100 cm^3 of blood (in g); Hgl_1—amount of haemoglobin in one erythrocyte (in 10^{-12} g); D—haemoglobin density (amount of haemoglobin per unit volume); L_1—haemoglobin surface of one erythrocyte (expressed in terms of Hgl μ^2); L_{100}—haemoglobin surface of the total erythrocyte number in 100 cm^3 of blood (expressed in term of Hgl m^2).

In the course of postembryonic development, as proved by our investigations (Table 1 and 3), the haemoglobin content and number of erythrocytes increase with age. Thus, among the breeds Yurlovskie golosistye one-day chicks have 14% more haemoglobin and 16% more erythrocytes than

Table 3

Breed	n	Haemoglobin	Erythrocyte number	Length of erythrocytes	Width of erythrocytes
Brown Leghorns	1	51	1.62	12.49±0.054	7.11±0.042
Yurlovskie golosistye	5	50.7	2.63	12.35±0.054	6.75±0.041

have hens aged 8—11 months. The rise of the respective indices in cocks is extended over a far greater period. When however the hens born in 1937 (12—20 months old) were compared with adult hens (over 2 years old), the results were similar.

The size of erythrocytes, on the contrary, diminishes with age, one-day chicks possessing those of the largest size. A sharper reduction of erythrocytes is observed during the first period of life, while later on, beginning from the age of 3 months, according to our investigation, the size variation of erythrocytes is sligtht, ranging within 0.5 of a micron. The same character of age variation is observed in the values of surface area, volume, haemoglobin surface of the erythrocyte and amount of haemoglobin present in one erythrocyte (O_1, V_1, L_1, Hgl_1). The values O_{100}. V_{100}, Hgl_{100} and L_{100} are increasing with age, and the alkalinity of the blood is also higher in adults.

b) Sexual Dimorphism. Most of the investigations on sexual dimorphism in animals based on their blood indices point to the fact that the number of erythrocytes and the content of haemoglobin are higher in males than in females [Riddle's survey (6)].

The results of our comparison of blood indices of fowls lead to the conclusion that the increase (in %) in values for cocks as against hens is rather significant.

This is liable rather to be the effect of the most intensive metabolism in cocks. It is corroborated in particular by statements of H. Mitchell and W. Haines (4), who disclosed that the rate of metabolism is 14.7% higher in cocks (adult) than in hens. As to young chickens which have not yet reached sexual maturity, the sex variation of their blood indices is slight, but goes on increasing with age. Thus, if in adult fowls differences in haemoglobin and L_{100} value amount to 26—29% in favour of males, in young 3-month Langshans the difference in haemoglobin constitutes only about 1.7% and in 5-month Brown Leghorns—15%; the increase in the L_{100} value is 0.5% in Langshans and 10.9% in Brown Leghorns. However, Benthams show already at the age of 7 months a difference in favour of males, which is equal to 29% with respect to haemoglobin value, and to 27% with respect to L_{100} value.

The appearance of sexual dimorphism at a more advanced age, as reflected by blood indices as well as by live weight, seem to us to be connected in Langshans with their sexual maturity.

c) Breed Related Differences. From comparison of blood indices in adult fowls of different breeds it follows that the larger breeds of fowls (Langshans and Yurlovskie golosistye) show higher values of haemoglobin content and number of erythrocytes than do medium and dwarf breeds. According to haemoglobin content and haemoglobin surface in 100 cm^3 of blood (Hgl_{100} and L_{100}) Langshans rank first, with Brown Leghorns following next and Benthams last. Yurlovskie golosistye investigated at the age of 8—11 months, showed a higher oxidation power of blood as compared to Langshans, Brown Leghorns and Benthams of the same age.

Contrary to Walther's (7) and Mehner's (3) statements to the effect that dwarf breeds of fowls possess erythrocytes of larger size, we found Brown Leghorns to possess erythrocytes of the largest size, while the smaller erythrocytes were observed in Benthams; Langshans are intermediate in this respect.

The alkalinity of blood was determined in Brown Leghorns and Langshans only and it was always found to be higher in the latter.

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PLANT PHYSIOLOGY

EFFECT OF HIGH TEMPERATURE ON VERNALIZED WINTER WHEAT

By A. K. EFEIKIN

(Communicated by N. I. Vavilov, Member of the Academy, 26. VIII. 1939)

The remarkable discovery of the vernalization phenomenon in winter plants was a starting point for Lyssenko to evolve his phasic development theory (1). The individual life of a plant consists, according to this theory, in running through a succession of phasic modifications sharply limited from each other, which eventually bring the plant to a state when it bears fruit. The phasic modifications are localized in the apical growing point of the stem and are claimed to be irreversible.

«A plant's cell with properties characteristic of the vernalization phase can by no means be reduced to its former condition (in which it was previous to vernalization)» declares Lyssenko(1), but no evidence has been produced by him in support of this statement. It is therefore very interesting to try experimentally whether the vernalization process is really irreversible; the more so as experiments of Gregory and Purvis (2) have furnished some evidence to the contrary. These authors failed to obtain heading plants from winter rye seeds, if the latter after vernalization were long (for 20 weeks) kept dry at ordinary temperature.

Our experiments were conducted with winter wheat Durable which on vernalization requires a temperature between 0 and 2° C during 40—45 days. We kept the temperature within this range for 50 days while vernalizing the seeds, 100% of which had already germinated. May 5 the vernalized seeds were planted into clay pots, 6 grains per pot. Simultaneously unvernalized seeds were planted into similar pots. The experiment was run in three sets. In the first set 5 pots after planting were immediately taken into an electrically

	Seedlings appeared above ground	Time of heading	Number of leaves on main stem
Unvernalized	11.V	Failed to head	11—13
Vernalized (control)	8.V	29.VI—14.VII	9—10
» (1st set)	7.V	Failed to head	11—13
» (2nd »)	8.V	2.VII*	9—10

*All plants did not produce ears; part of them were not to be distinguished from unvernalized plants.

illuminated chamber varying in temperature between 27 and 33° C. The rest of the pots both with vernalized and unvernalized seeds were left in the room on the window-sill, where the temperature was varying from 13 to 17° C, until the end of May. Then the temperature grew warmer in the room as it did outside. The pots in the chamber remained there for 6 days (from May 5 till 11) and were then transferred to the sill to make further growth with the other plants under in-door conditions. In the second set the same number of pots (5) received a similar treatment in the same chamber during the same time (6 days), but they were started to receive it when two leaflets had appered on the plants (May 13), and after the third had made its appearance (May 19), they were placed on the sill to the rest of the plants. The 3rd set consisted of vernalized plants which were kept with the unvernalized ones on the sill throughout the experiment to serve as control. The development of plants under these various kinds of treatment can be compared in the table.

Fig. 1. Condition of plants on July 19. *1*, unvernalized; *2*, vernalized (control); *3*, vernalized from 1st set; *4*, vernalized from 2nd set.

Fig. 2. *1*, growing cone in an unvernalized plant; *2*, growing cone in a vernalized plant from 1st set (x50); *3*, spike of a vernalized control (drawn by Elagin in natural size).

The plants, as they looked on July 19, i. e. 75 days after sowing, are represented in Fig. 1. The third set of vernalized plants (control) bore 9—10 leaves on the main stem and had their ears formed since July 14. The unvernalized plants had not come into ear and continued developing new leaves. The vernalized plants in the first set, which were treated with higher temperature immediately after sowing, had not begun heading either and were not to be distinguished from vernalized plants. The growing cones of their stems were perfectly similar, too. Under a magnifying power of the binocular glass they showed a similar kind of tubercles running in a slightly oblique circle around the cone. Only leaves develop from such tubercles, while spikelet tubercles are usually arranged on two opposite sides of the growing cone alternately. Fig. 2, *1* and *2* are representations of growing cones from unvernalized and 1st set plants respectively, magnified 50 times. A spike of vernalized controls is shown in Fig. 2, *3* in natural size. At the time when

the vernalized controls had their spikes fully developed, the plants in the first set and the unvernalized plants showed no signs of differentiation of spikelet tubercles on the growing cones. Both were at a very early stage of development, that of leaf-formation, according to the interpretation of Zabluda (3). It will be obvious that the winter rye plants first vernalized and then subjected to the action of high temperature failed to produce ears and looked like unvernalized plants.

The only reason which may be put forward to account for this similarity in behaviour of vernalized and unvernalized plants is the reversibility of the vernalization process by way of high temperature treatment.

Another fact to note in the experiment is that in the second set most of the vernalized plants which were under the influence of high temperature when the 3rd leaf was forming on them, have produced ears while some have not. The latter just as the plants of the first set are much alike to the unvernalized plants. In other words, part of the plants are as it were devernalized, while others have brought their development to an end, i. e. up to fruiting. This should be taken to mean that the process of vernalization is reversible until a certain developmental phase is reached by the plant, and it is only then that it becomes irreversible.

How long can the reversibility of vernalization last with the plant and what factors account for the limitation—these questions will make the subject of a special work. It may be said in a preliminary way that the process is linked up with structural and morphological modifications which arise in the growing cone. According to Filipchenko (4), the differentiation of spikelet tubercles in wheat starts at an early period of development and is preceded, according to Melnikov (5), by internal structural changes in the growing cone—formation of plastids, chlorophyll, and so on. Very likely these structural changes impose limitations upon the reversibility of the vernalization process.

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PLANT PHYSIOLOGY

TILLERING OF PLANTS AS INFLUENCED BY VERNALIZATION

By I. N. KONOVALOV and V. N. FROLOVA

(Communicated by A. N. Bach, Member of the Academy, 9. VIII. 1939)

The question as to why the plants should increase in yield in response to vernalization involves the study of their tillering under these conditions. From the theoretical point of view it is indeed possible to influence the process of tillering by way of vernalization, since the existence of differences between spring forms and winter forms as regards their development is a fact well established by many investigators.

A distinctive feature in the development of winter forms—according to the authors concerned with the question ([2],[5],[6],[8] and others)—is their continuous tillering and inability to produce fruit during the first year after spring sowing. On the other hand, the spring forms sown in spring have their spikes and fruits formed within the same year. The correlation between the intensity of tillering in winter wheats and the conditions for their development was also stated by Grantam ([11]). And at long last for the spring wheats the dependence of their tillering upon the conditions of development was reported by the authors dealing with the questions of drought-resistance ([1],[3],[7],[9],[10] and others).

But the conditions under which the plants make their growth are essentially modified by vernalization, and therefore the influence of the latter upon the productivity of tillering offers a great theoretical and practical interest. The importance of the question is still more obvious, if one considers that the increase in tillering was treated in some of the works as a factor responsible for the increase of the yield in vernalized plants. We can refer here especially to a paper by Konev ([4]), of the Moscow Regional Station for Crop Industry. He points out, while reporting the results of the vernalizational work in the Moscow province, that the effect of vernalization is to enhance tillering in oats and spring wheats.

On these considerations the work on the response of tillering to varying intervals of vernalization was included into our inquiry into some other problems connected with the structure of the yield. The experiments were run under greenhouse conditions at this Institute in the summer of 1939. The plants tested were soft wheat, *Lutescens* 062, and hard wheat, *Hordeiforme* 010. In the case of *Lutescens* the length of the vernalization period was 4, 8 or 12 days, while it was 5, 10 or 15 days in the case of *Hordeiforme*. The controls were grown from dry seeds or else from soaked and germinated seeds. All plants were raised in the vessels (20×20), each vessel containing

Table 1

Effect of Vernalization upon Tillering of Spring Wheat
Lutescens 062 (grown in greenhouse, summer 1939)

Experimental sets	Number of normally developed shoots per vessel (in 8 plants)	Underdeveloped shoots per vessel (in 8 plants)
Dry control	20.8	1.2
Soaked and germinated control	20.8	1.6
4-day vernalization	21.6	0.4
8-day »	18.8	0.4
12-day »	18.72	0.25

Table 2

Effect of Vernalization upon Tillering of Spring Wheat
Hordeiforme 010 (grown in greenhouse, summer 1939)

Experimental sets	Number of normally developed shoots per vessel (in 8 plants)	Underdeveloped shoots per vessel (in 8 plants)
Dry control	21.0	2.0
Soaked and germinated control	22.8	2.0
5-day vernalization	21.8	0.2
10-day »	22.25	0.25
15-day »	21.4	0.2

8 plants. There were 6 vessels in each of the experimental sets. The results are summarized in Tables 1 and 2.

From the tables it is evident that the development of plants is essentially controlled by vernalization. Changes in the extent of tillering arise eventually from the presowing treatment of seeds. It turns out that among unvernalized plants those send forth a larger number of shoots whose seeds have been planted in soaked and germinated condition compared to the controls grown from dry seeds. Among the vernalized plants the number of shoots produced is in inverse proportion to the length of the vernalization period within the range of intervals required for vernalization of spring forms. The conclusion to be drawn from these tables is that the development of plants being furthered by vernalization, the reproductive phase is reached earlier and there is no time for a complete tillering. One is apt to conclude, moreover, that more profuse tillering of the plants from soaked and germinated seeds is conducive to better yield than that which can give vernalized plants. But this would be a premature conclusion indeed, since it is at variance with the facts of favourable influence of vernalization on the yield, which are known from industrial growing of plants and have been observed in our experiments, too. As a matter of fact, the enhanced tillering of plants from soaked, germinated but unvernalized seeds is not followed by a full development of lateral shoots. And we see from the tables that the ratio of underdeveloped shoots is high in these plants, as it is also in the dry control. That lateral shoots fail to develop normally when vernalization is eliminated, is still more conspicuous if the development of spikes is examined, but this item will be discussed in the following article.

Here we are already able to state that the increase of the yield in response to vernalization is by way of a better development of the spikes on the main shoots rather than through enhanced productivity of tillering.

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PLANT PHYSIOLOGY

HEADING OF PLANTS AND THE NUMBER OF SPIKELETS IN A SPIKE AS INFLUENCED BY VERNALIZATION

By I. N. KONOVALOV and V. N. FROLOVA

(Communicated by A. N. Bach, Member of the Academy, 9. VIII. 1939)

After successive tillering the further important items in the development of plants toward a high yield are the size of the spikes formed, the number of spikelets in a spike, the number of grains in a spikelet or in a spike and at long last the absolute weight of grains (weight of 1000 grains). How the above indices are affected by vernalization, is therefore a question of considerable interest. That it is important to approach the problem of vernalization from these angles is substantiated by the works of Sabinin (1), Sapehin (2), Percival (4), Kiesselbach (3) and others. Sabinin has found the structure of the yield to depend on the mineral nutrition of plants. Sapehin pointed out that the number of spikelets in a spike is related to the length of the light stage from its start until heading. Salmon and Grantam and Graff obtained plants of varying degrees of sterility by varying the conditions of their development. Percival while describing the structure of the yield and some particulars in the development of wheats under favourable and unfavourable conditions reported a variation in the above yield indices according to the conditions, under which the respective plants had made their development. Great interest belongs also to the data published by Kiesselbach. He investigated the influence of various environmental factors, as date and depth of planting and other, upon the development of the spike and found the latter to depend strongly on those external conditions, especially on the date of planting.

In view of all these facts we started studying how heading and the number of spikelets in a spike are affected by the length of the vernalization period. The experiments were conducted under greenhouse conditions at this Institute in 1939. The experimental material consisted of a soft variety *Lutescens* 062 and a hard variety *Hordeiforme* 010. The plants were grown in vessels (20×20). Each vessel contained 8 plants. The humidity of the soil in the vessels was 60% of its total moisture capacity. The amounts of fertilizers introduced were as follows: N, 0.75 g; P_2O_5, 0.5 g; K_2O, 0.5 g per vessel. The length of vernalization in the case of *Lutescens* 062 was 4, 8 or 12 days; in the case of *Hordeiforme* 010—5, 10 and 15 days. And there were two sets more in both cases: one consisted in planting dry seeds, while in the other the seeds were soaked and allowed to germinate before planting, but no vernalization was applied.

The results are presented in Tables 1 and 2.

Table 1

Heading and Number of Spikelets per Spike as Affected by Vernalization in Spring Wheat *Hordeiforme* 010 (grown in greenhouse, summer of 1939)

Experimental sets	Spike per vessel (in 8 plants)		Number per vessel of spikes bearing the following numbers of spikelets respectively				Total number of spikelets per vessel (in 8 plants)
	normally developed	underdeveloped	5	10	15	20	
Dry control	21.0	—	—	3.0	18.0	—	216.0
Soaked and germinated control	21.8	1.2	—	2.2	19.6	—	240.0
5-day vernalization . .	21.6	0.2	—	2.4	19.2	—	259.5
10-day » . .	22.5	—	—	1.0	21.5	—	265.0
15-day » . .	21.6	—	—	2.2	19.4	—	243.5

Table 2

Heading and Number of Spikelets per Spike as Affected by Vernalization in Spring Wheat *Lutescens* 062 (grown in greenhouse, summer of 1939)

Experimental sets	Spike per vessel (in 8 plants)		Number per vessel of spikes bearing the following numbers of spikelets respectively				Total number of spikelets per vessel
	normally developed	underdeveloped	5	10	15	20	
Dry control	19.6	1.2	0.2	4.0	15.4	—	172.6
Soaked and germinated control	19.4	1.4	0.4	4.8	14.2	—	179.6
4-day vernalization . .	21.6	—	—	4.0	17.6	—	205.0
8-day » . .	18.8	—	—	1.6	17.2	—	208.6
12-day » . .	18.72	—	—	1.22	17.5	—	187.0

Some interesting points are to be noted in analyzing the data referred to here. In the first instance we find the normally developed spikes to have increased in number in response to vernalization. In the case of *Lutescens* their number is highest with 4-day vernalization, in the case of *Hordeiforme* with 10-day vernalization. It is very likely that by keeping under control the factors which must combine to secure successful vernalization in various wheat samples, we shall be able to increase the productivity of tillering as well as the number of normally developed spikes with a highest content of spikelets in them. The ultimate solution of this problem is the aim of further investigations.

The second interesting point to note is an increase in the number of large spikes containing 10 to 15 normally developed spikelets.

At last our tables show an increase in the total number of normally developed spikelets per vessel. This is, probably, because better conditions for the development of the spikelets in the spike are created by vernalization. Corroborative evidence of this supposition is furnished by successful deve-

lopment of the topmost and the lowest spikelets in the spike which, as a rule, are poorly, if at all, developed in the controls.

Another circumstance favourable for the yield is that the plants go at one through the various phases of development, especially heading and flowering, and there is no lagging behind among them. If the plants head or flower disorderly, a large number of empty spikelets are formed. Thus, in our winter experiments, the number of empty spikelets per spike was 4.08 in the dry controls and only 2.68 in vernalized plants. This difference is likely to go well down, if the plants should be grown in summer, but it cannot possibly be expected to vanish especially in late forms. In this connexion it is well to mention some interesting facts observed in growing winter wheats at a high temperature when the action of low temperature was entirely eliminated. Under these conditions unvernalized plants of winter varieties Ukrainka and *Lutescens* 329 had a considerable number of their spikelets empty even in the second and third generation. Sometimes the entire spikes were as good as empty. This phenomenon was not, however, observed in vernalized plants.

We thus reach the conclusion that where the plants are not exposed to the action of drought and dry winds, the favourable effect of vernalization on the yield is chiefly by way of better development of the spike and its organs. In arid regions the influence of vernalization is stronger still, because the vernalized plants escape the action of drought and dry winds, but here the yield is increased by way of better tillering of grains.

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PLANT PHYSIOLOGY

SELECTION OF SPECIFIC MICROFLORA FROM THE SOIL'S MICROBIC COMPLEX OF ROOTS OF PLANTS

By A. A. ISSAKOVA

(Communicated by A. N. Bach, Member of the Academy, 7. VIII. 1939)

In microbiological, pedological and physiological literature much attention is paid to the value of the microbiological factor in the life of plants.

The presence of live roots in the soil brings about considerable quantitative as well as qualitative changes in the microflora of the soil. Facts confirming this doctrine may be found in the works of Starkey, Krassilnikov, Gräf, Obrastzova, etc. There are considerably less indications as to how the changes in the qualitative composition of the microflora are related to cultivation of various plants. The purpose of this study was to find out, how specific the bacterial forms, selected by the roots, are.

The factors which determine the selection of microorganisms may be the root secretions of the plants and the inherent ability of the root concerned to absorb definite mineral ions from the soil complex. These factors may be used as a basis in working out the problem of adapting certain components of the soil microflora to a synergetic form of life with a higher plant.

The study of the problem of the specific selection of bacterial forms by plants was made by us for two groups of bacteria: the azotobacter group and fluorescence, adopted to life in an elective medium with tyrosine. The bacteria of these groups isolated from the roots of various plants showed clearly expressed differences in the structure and pigmentation of their colonies which made the study of these organisms considerably easier.

Azotobacter Group. The material for the test we obtained usually by a dense sowing of plants in clay pots. The soil used in these experiments was a medium-podzol argillaceous soil with pH = 6.2. The following plants were studied: barley, hemp, flax, lupine, soya, kidney bean, horse bean, etc. The azotobacter was detected on the roots of all plants. The isolated pure cultures showed essential differences in the type of their colonies and in pigmentation. This is brought out in Fig. 1.

Some forms, e. g. the hemp azotobacter, were distinguished by their fine-grained structure and almost black pigmentation. Other forms, e. g. the flax azotobacter, consisted of colourless drop-like colonies, some forms had a folded structure, and others were distinguished by the fact that they gave mucous slipping colonies. This whole variety of azotobacter forms was isolated from the same soil.

One of the characteristic features of the isolated forms is their weak power to fix nitrogen, not above 0.1—0.2 mg to 1 g of energetic material. Tests of these

forms in various mediums —mannite, glucose and sodium benzoate—showed that the differences observed are quite stable and do not vary when the energetic material is changed.

The adaptation of these forms to a synergetic life affected these forms very much, almost all of them quickly became incapable of developing in synthetic mediums. After 3—4 successive inoculations the cultures already became incapable of developing in Ashby medium, unless root decoction from barley was added. The addition of root decoction from horse beans had a variable

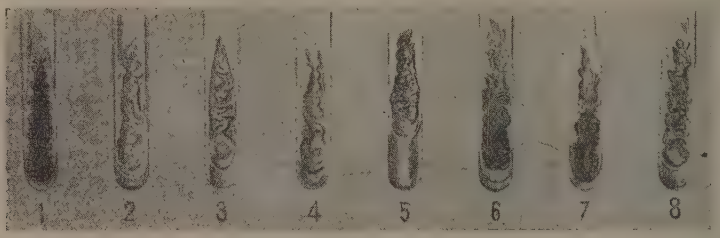

Fig. 1.

effect upon the development of azotobacter, this effect was strongly positive in the case of azotobacter from pea plant, and no less negative for the azotobacter of oats.

Examination of these forms for their ability of inducing the formation of roots in the *Sensaviera cylindrica* Bog. showed them to fall into 3 groups. Some gave root-formation in 53 days (azotobacter from flax, soya, beans), others in 58 days (azotobacter from barley, horse beans), and others again

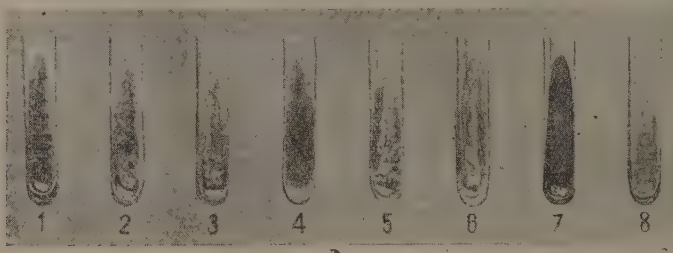

Fig. 2.

in 65 days (azotobacter from lentil, lupine). The experiment was continued for 90 days, but neither the control nor the azotobacter of hemp gave root-formation. All these facts show that the azotobacter forms, selected by various roots from the same soil, differed not only morphologically, but also in their biochemical indices.

Fluorescence Group Forming on Tyrosine. From the roots of the same plants forms of bacteria were isolated which developed in an elective tyrosine medium. They can all be referred to the fluorescence group. The characteristic feature of these microorganisms is their capability of secreting tyrosinase into the surrounding medium. This capability is expressed in various forms with various intensiveness. A striking case in point are the bacteria of flax and hemp, which are highly capable of secreting tyrosinase. Other bacteria, however, e. g. those of vetching, lentil and kidney bean, are lacking this capacity. The final decomposition

products of tyrosine under the influence of these bacteria are also variable, e. g. the bacteria of flax and hemp give brown-coloured products, the bacteria of horse bean and lupine give melanin-coloured products, while some of the bacteria forms do not give coloured decomposition products at all (Fig. 2).

These differences in the colour of the medium could also have been due to the bacteria losing their enzymic activity. There are indications in literature to the effect that some mineral substances, e. g. iron and calcium, increase the activity of tyrosinase. We observed the development of bacteria in mediums to which iron and calcium were added, and which we all adjusted to a pH=7.0.

The results showed that almost all of the isolated bacteria forms reacted negatively to the addition of iron, the activity of the tyrosinase in all the forms was sharply depressed. The addition of chalk to the medium caused a phenomenon of the opposite kind, we observed a clear-cut increase in the activity of the tyrosinase in comparison with the normal medium, i. e. the addition of 0.1% tyrosine to Vinogradsky's dilute mineral medium. In this case it may be possible to explain the absence of active tyrosinase in some of the forms by the fact, that in adapting themselves to a synergetic life with a certain plant they got into a medium low in calcium. This could happened either if the plant did not discharge soluble calcium forms in the form of root secretions, or if it absorbed calcium ions from the soil in very great quantities, which caused a deficiency of this element in the zone in contact with the roots.

Examination of the isolated bacteria for root formation in the *Sensaviera cylindrica* Bog. also showed the variable nature of these forms. Some bacteria gave the effect in 53 days (the bacteria of flax, beans, horse beans, lupine), others in 65 days (the bacteria of hemp and lentils), and still others only in 73 days (the bacteria of vetchling).

In summarizing this work it may be said that the plant is the factor which selects microorganisms from the soil layer. The tendency of this selection is in strict conformity with the physiological or biological peculiarities of the plants and may depend upon the nature of the root secretions, and also upon the nature of the absorption of mineral ions from the soil by plants.

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PLANT PHYSIOLOGY

FORMATION OF ENDOSPERM IN HARD AND SOFT WHEATS

By V. G. ALEXANDROV and O. G. ALEXANDROVA

(Communicated by A. A. Richter, Member of the Academy, 28. VIII. 1939)

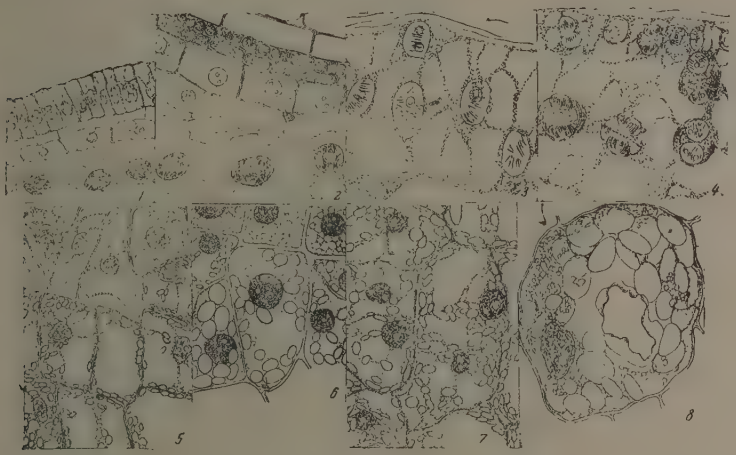
Double fertilization in cereals is known to give rise first of all to energetic formation of the endosperm. But the stimulus given by the fertilization act is not confined to formation of the endosperm and embryo. A strong growth in length of what will in future be the fruit of the cereal also receives its start with fertilization. This elongation of the kernel ovary is in turn attended by growth of that part of the endosperm which forms a wall on the inner suface of the nucellus remains. The result is that during the first phase of endosperm formation a kind of blastula is formed consisting of peripheral endosperm cells arranged parietally, which envelop the cavity of the former embryo-sac and the more dense basal part. The latter is an embryonal issue which grows to fill the cavity of the blastula and form the inner tissue of the endosperm (1). The elongation of a young kernel is well ahead of its growth across, which starts only during one of the further developmental phases (2).

At least two phases are therefore to be distinguished in the formation of the endosperm of a cereal kernel. The first is when the growth in length of a young kernel is most intensive, and the blastula-like character of the forming endosperm is most distinct. During the second, later phase the kernel is growing across, the endospermal cavity is being filled up and the filling of the kernel is the result. According as the process of formation and growth of endosperm cells is more or less intensive and long at this second phase, the lobes which appear on the kernel show varying degrees of distinctness and the furrow varies in depth. Naturally enough, the peripheral part of the endosperm which is morphologically a blastoderm, follows the growth of the endosperm, when it is increasing in thickness. It is only the region of the furrow (placental chalazal region) which is not involved in the process, showing clear signs of elongation, while its growth in thickness is very poor (2). Here the commissure uniting the two lobes (decks) is forming. Hence the periphery of the endosperm in the region of the furrow is nearly unliable to dilation under the pressure of the growing inner part of the endosperm. This accounts partly for the different structure of the peripheral endosperm in the region of the furrow compared to what it is on the sides of the kernel. Another responsible cause is obviously the topography, that is the fact that the placental chalazal apparatus and the antipodals adjoin to this region (1).

It will be apparent that by way of analyzing the history of the development of the various parts of the endosperm, we are likely to arrive at a clear understanding of its peculiar structure. Through inquiring into the development

history of a kernel we will obtain the possibility to look upon the endosperm from different angles and thus to clear up the relations about this practically and theoretically important component of the kernel which includes a variety of nutrient products.

In our studies on the development and formation of the endosperm in various wheats we fixed our attention upon a certain peculiarity in the formation of cells in both the peripheral and central part of the endosperm which had not yet been satisfactorily investigated. This was a strong vacuolization of the endospermic cells during the earliest phases of their development, when the cell walls had not yet been formed and the nuclei were dividing intensively—a period which can properly be called embryonal with regard



to the cells of the endosperm. We shall here describe this phenomenon on some few examples and in general trace the course of formation of the endospermic issue.

Fig. 1 shows a portion of a cross-section through the middle of a young fruit of winter wheat Moskovskaya 2411 in the period of endosperm formation. The epithelium of the nucellus is well expressed in the form of high cells closely pressed together. The inner layers of the nucellus tissue are in progress of disintegration. They are contiguous to the endosperm which forms a protoplasmic belt including fairly large nuclei with perfectly distinguishable nucleoli varying in number from one to four. A portion of a similar cross-section through the young fruit of an early northern variety (3) is represented in Fig. 2. But the development is at a later period here than in Fig. 1. The nucellus tissue is destroyed still more considerably. Large vacuoles have been formed near the nuclei of the endospermic layer. The structure of the nuclei themselves has essentially changed. Their contents are no longer a distinctly granular structure, but it is fibrous as in a nucleus which is about to divide. In face of a pronounced vacuolization of the young endosperm cells which have combined to form a continuous syncytium, there are no signs whatever of formation of cellular walls. The nuclei division, moreover, is not prevented by the presence of large vacuoles. Inwards from the parietally located layer of the growing endosperm are the remains of the cavity of what was formerly the embryo-sac containing various substances in solution.

Especially representative is the vacuolization of the parietal endospermic syncytium in hard wheats. Fig. 3 shows a portion of a longitudinal sagittal

section through the lower half of a young fruit of variety *Hordeiforme* 027. Vacuolization has nearly reached its limit. The largest nuclei in the loops of the protoplasm are all around encircled by vacuoles. The condition of the blastoderm on the back side of the blastula-like formation is represented by this figure. Its ventral side is shown in Fig. 4. Here the nuclei are dividing intensively in the vicinity of the placental chalazal apparatus, though the vacuolization of the blastoderm syncytium is as strong as on the back side. Almost all phases of nucleus division are seen in Fig. 4. The protoplasm around the nuclei is very scarce here too. On the back side the nuclei are also ready to enter into the process of division. The isolation of the parietally located endospermic syncytium from the cavity of the former embryo-sac is quite distinct throughout the initial phases of endosperm development, as it is the case with the blastoderm of embryo in a number of animal organisms.

We thus find a strong vacuolization of the protoplasm to attend the intensive division of nuclei in the parietally situated syncytium which represents the initial stage of development of a forming wheat endosperm. Though the meristematic nature of the formation described is obvious, yet the presence of a strongly developed system of vacuoles, which can moreover be so easily observed, is somewhat at variance with the usual representation of the protoplasm structure in the meristematic cells. We have here to remind the reader that for the young cells of various plants the presence of a complicated system of vacuoles consisting of thin channels and which needs special methods of vital staining in order to be detected has been established beyond all doubt (4). The peculiarity of the structure of the forming endosperm receives added strength from the fact that the cellular walls are entirely absent. To interprete this structure properly at the present time is a matter of considerable difficulty. It may be supposed, however, that the ultimate rôle of large vacuoles is to facilitate the storage of reserve matter, starch and protein, in the cell. It is worthy of note that the cellular walls appear in the endosperm at the time of formation of starch grains, of the so-called plastid starch (5). And the fact that the accumulation of starch in the anatomical elements of the endospermic tissue has set in interfers in no way with the division of nuclei. The latter are not infrequently seen in the condition of anaphase, surrounded by a ring of small elliptical starch grains.

It is not until an appreciable portion in the cavity of the former embryo-sac has been filled by the new-forming endosperm that the cellular walls start formation in the endosperm tissue and spread from the periphery to the centre. Fig. 5 shows a portion of a sagittal cut through the ventral side of a young kernel from *Hordeiforme* 027. The cellular walls have already made their apperance; in the starchy part of the endosperm the plastid starch grains are rather numerous, and in the aleuronic layer tiny aleurone grains become visible. The separation of the aleuronic layer can be discerned even at earlier phases of the development of the endosperm (Fig. 4). If we were to compare the size of the vacuoles with that of the cells first in the aleuronic layer when it is starting development (Fig. 4) and then in the already differentiated cells (Fig. 5), it would be obvious that the vacuoles are degrading in size with the progress of cell differentiation. That they decrease in size and increase in number has been established definitely by Dangear (4).

Even at this very early phase of development the physiological condition of cells in the young aleuronic layer differs from what it is in the starchy part of the endosperm. With the method we used for fixing the material under investigation (alcohol added with small amounts of acetic acid), plasmolysis was set up in the cell contents of the aleuronic layer, but no signs of it could be detected in the cells of the starchy part of the endosperm, though the vacuoles were markedly larger in them. This is probably because the vacuoles

of the young aleuronic cells contain much stronger solutions of protein substances than do the cells of what will in future be the starchy tissue of the endosperm, where sugar solutions seem to predominate. The different condition of the vacuole contents is concomitant to a difference in the condition of the protoplasm and the cellular organism as a whole.

Fig. 6 shows a portion of a cross-section, which refers to the lateral side in the central part of a filled but not yet ripe kernel, a late variety from Finland (v. *erythrospermum*). In the cells of the aleuronic layer small rounded vacuoles are numerous which further will turn into aleuronic grains. In some wheats (*Tr. Timopheevi*, rigid varieties from Afghanistan, v. *erythrospermum*) protein crystalloids are distinctly visible in the aleuronic grains. The process of diminution of vacuoles is complete in the cells of the aleuronic layer, but in the starchy part of the endospermic tissue the vacuoles are very large still. So they are both in the peripheral (Fig. 6) and central regions of the endosperm (Fig. 7) (v. *erythrospermum* 341) of a young full-sized but not yet matured kernel (stage of first ripeness).

At the expiration of the first ripeness phase, when chondriosomal starch makes its appearance and the cellular nuclei in the endosperm start disintegration, the vacuole contents in the endospermic cells becomes more dense and gives clear response to protein reaction. Fig. 8 represents a cell from the starchy part of the endospermic tissue. The kernel is about to complete its first ripeness and the cell has a large vacuole in its centre, whose contents, shrunk in response to treatment, give a positive reaction to protein. Along with large plastid starch grains there are seen small polyhedral grains of the chondriosome starch. They are enveloped with a fibrous mass whose reaction to protein is not so pronounced as in the case of vacuoles, yet it is positive, too. As the kernel ripens, the reaction to protein of the dense mass between the starch grains grows more and more definite, though the mass itself decreases in amount appreciably.

Consequently, two ways may be traced for the proteins to accumulate in the endosperm of a ripe kernel. Some proteins are formed and laid in store in the vacuoles. Their capacity of extension is comparatively poor. The other are a result of protein metamorphosis of the cell protoplasm. They are quite elastic and can be extended easily.

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AGROPHYSIOLOGY

INFLUENCE OF SOIL TEMPERATURE ON THE YIELD AND UPTAKE OF NUTRIENT ELEMENTS BY THE SUNFLOWER

By T. T. DEMIDENKO and V. P. GOLLE

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The thermal regime of the soil greatly influences the development of plants, giving rise to processes connected with the uptake of water and nutrient elements by plants and also to respiration processes. Not all agricultural plants are in need of the same conditions for growth.

That plants react dissimilarly to the temperature conditions of the soil and air regime is due to the fact that the protoplasm of each species of plants, as the life-bearer, exhibits specific peculiarities; biochemical reactions may take place in it only under certain temperature conditions. For some plants these temperature conditions should be high, while on others the latter have a negative influence. The overground and underground parts of certain groups of plants have their own temperature optimums.

Effect of Soil Temperatu

	Transpiration coefficient	Yield of dry mass per plant in g			Content		
					N		
		vegetative mass	seeds	whole plant	in %	per vessel	for 100 days
At lowered $t°$							
Control (soil without fertilizers)	738.4	23.9	4.2	28.1	1.678	0.472	0.393
Soil + PK	680.5	27.5	5.8	33.3	1.125	0.375	0.313
» + NK	596.3	110.4	32.4	132.8	1.915	2.543	2.119
» + NP	580.4	118.7	35.6	154.3	1.926	2.971	2.476
» + NPK	505.8	125.7	40.2	165.9	1.997	3.313	2.761
At elevated $t°$							
Control (soil without fertilizers)	738.5	25.6	5.4	31.0	1.684	0.522	0.435
Soil + PK	686.8	30.6	6.8	37.4	1.247	0.466	0.388
» + NK	606.5	120.8	37.5	158.3	1.937	—	—
» + NP	585.6	135.6	48.7	179.3	1.934	3.468	2.890
» + NPK	515.6	140.6	45.2	185.8	1.957	3.636	3.085

A number of investigators showed that temperature conditions favourable for the plant concerned are liable to variation during its vegetative life. Some plants develop better at low temperature while young, but grow better at higher temperature in their middle stage of development; others, on the contrary, while young react positively to high temperature in the surroundings, and need some decrease in it in the middle stage of development.

The life of a plant depends on the complex of factors, of which some are taken into account and others are not, but all influence the development of plants greatly. One of the important conditions for clarifying the situation is to find out the temperature optimum which to a considerable extent controls the trend of the biochemical reactions in the plant organism ([1–5]).

Considering the mineral supply to the plants as the main factor, we studied the influence of the temperature on the crop and the uptake of nutrient elements by the plants. The results of the experiments with sunflower are given in the table.

In order to get a high yield, 0.3 g per kg of the active principle, nitrogen, phosphorus and potassium, was introduced under the sunflower. The method of experiment was adopted from the work of A. A. Polyarny ([1]). The vegetation vessels were placed in galvanized baths, consisting of a box with holes, through which it was possible to raise and lower the vessels while watering the plants. The vessels were on metallic stands, the baths were fastened in wooden boxes with covers made of veneer lined with felt. In the low temperature bath the space between the bottom of the iron box and the wooden floor was filled with saw-dust, and the temperature was decreased by passing water continuously through the iron box with the vessels. High temperatures were attained by means of an electric heater, which made it possible to keep the temperature at the requisite height. The temperature was usually determined every 2 hours by means of thermometers installed in each vessel in the watering tubes. The low temperature fluctuated usually from 13 to 17.5°, and the high one from 25 to 35° C.

res on the Yield of Sunflower

of nutritive substances

P_2O_5			CaO			MgO		
in %	per vessel	for 100 days	in %	per vessel	for 100 days	in %	per vessel	for 100 days
0.694	0.195	0.163	0.256	0.353	0.294	0.567	0.149	0.124
0.759	0.253	0.211	1.068	0.356	0.297	0.524	0.174	0.145
0.574	0.702	0.635	1.137	1.510	1.425	0.514	0.683	0.569
0.685	1.057	0.881	1.138	1.756	1.463	0.524	0.809	0.674
0.794	1.317	1.098	1.116	1.851	1.543	0.486	0.806	0.671
0.785	0.243	0.208	1.365	0.423	0.353	0.653	0.202	0.168
0.824	0.308	0.257	1.345	0.424	0.353	0.494	0.184	0.153
0.654	1.085	0.863	1.256	1.988	1.657	0.485	0.768	0.640
0.754	1.352	1.127	1.214	2.177	1.814	0.513	0.920	0.767
0.896	1.665	1.388	1.118	2.077	1.713	0.425	0.790	0.658

Plants exposed to various heat regimes of the soil showed considerable differences in development. They developed especially well at high temperature. When the soil temperature continued high, flowering set in sooner than at low temperature. At an increased temperature the sunflower formed flowers 5—6 days sooner than it did at low temperature. The time of ripening was also affected by the temperature. In the cases where the plants were provided with a sufficient quantity of phosphoric acid, they get ripe more quickly than when there was not enough of it. At different temperatures the plants evaporated different quantities of moisture. In the control vessels they transpired less at low temperature than at high temperature. When phosphate and potassium fertilizers were introduced and the temperature continued high, they evaporated more water than at low temperature. When nitrogen and potassium were introduced and the temperature continued low, the transpiration coefficient decreased. With the nitrogen-phosphate fertilizer the sunflower evaporated more water at high than at low temperature, and finally when fully fertilized at high temperature the transpiration coefficient was considerably higher than at low temperature.

Varying temperature affected the absorption of nutrient elements and also the yield. The weight of the sunflower stems was higher in all cases at high than at low temperature. Although this difference in many cases is considerable, yet in some its values are small. The grain yield was higher in all cases at high than at low temperature. The value of the total yield is also higher at an increased temperature than at a decreased one.

The temperature conditions affected the utilization of the nutrient elements of the soil. When phosphorus and potassium are introduced, the yield is raised considerably at a high soil temperature. The introduction of nitrogen and potassium under the same conditions lowers the yield of stems and leaves, but the grain yield increases greatly. When nitrogen and phosphorus are introduced, the stem and seed yield also increases, and when fully fertilized, the increase due to high temperature is quite pronounced. Calculation of the transpiration coefficient of plants grown at different soil temperatures shows that in all cases the transpiration coefficients of the plants were higher at high than at low temperature, but this rise was very small, from which we draw the conclusion, that if the plants are provided with a sufficient quantity of nutrient substances, a rise of the temperature will not increase the transpiration.

A point of interest is the uptake of the nutrient elements by the plants as related to the soils temperature. We determined the uptake of nitrogen, phosphorus, potassium, calcium and magnesium by the plants. In minus-fertilization sets we found that in 100 days, during which the plants absorbed the nutrient elements, the uptake of nitrogen by the plants was more intense at high than at low temperature. When phosphorus and potassium were introduced into the soil, in this combination of fertilizers the plants absorbed considerably less nitrogen. On full fertilization the absorption of nitrogen is different at both temperatures.

It should be noted that in the control case the plants in 100 days absorbed considerably more phosphorus at high than at low temperature. When nitrogen and potassium were introduced into the soil and the temperature was high, more phosphates were absorbed, too, than at low temperature. But when the plants are fully fertilized, we observe that high temperature has positive influence on the uptake of phosphates by the sunflower.

The control plants, having grown on soil without fertilizer, absorbed more potassium at high than at low temperature, and when fully fertilized, although they absorbed more than in the former case, the difference was insignificant.

The temperature also affects the absorption of calcium. The determination of its percentage in the plants grown with full fertilization shows that in 100 days the sunflower absorbed more of it at high than at low temperature, though its percentage in the plants is the same at both temperatures.

Curious picture is observed in the uptake of magnesium—in the control case the sunflower absorbed it more at high than at low temperature, and in the case with full fertilization the plants contained less of this element at high temperature.

Summarizing the above-mentioned, we note that:

1. The sunflower develops much more quickly at high than at low temperature, beginning to flower 5—6 days sooner than it does at low temperature.

2. At high soil temperature the development cycle of the sunflower is quicker and ends considerably sooner.

3. When there is a deficiency of nitrogen in the soil, a rise in the soil's temperature increases the yield in comparison with the corresponding case at low temperature, and when phosphoric acid is deficient in the soil, the yield's increase reaches 36.2% under the influence of high temperature, while it is only 2—5% in the case of potassium deficiency. Although the plants developed in a shorter time at high than at low temperature, they absorbed more nitrogen.

4. The temperature affects the mobilization of nitrogen and phosphorus in the soil and does not affect the mobilization of potassium.

5. The transpiration coefficient of plants grown in soils with varying temperatures shows a narrow range of variation on the whole, since the addition of fertilizer changes their values more considerably.

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AGROPHYSIOLOGY

INFLUENCE OF RELATIVE AIR HUMIDITY ON THE YIELD AND UPTAKE OF NUTRIENT ELEMENTS BY THE SUNFLOWER

By T. T. DEMIDENKO and V. P. GOLLE

(Communicated by A. A. Richter, Member of the Academy, 1. IX. 1939)

The experiment for studying the influence of the relative air humidity on the uptake of the main mineral elements and on their utilization by the plant at various relative air humidities was performed in aqueous and soil cultures. The plants were cultivated in two glass chambers, the air of which was changed through tubes at the top of the chamber, where carbon lamps were installed that burned for 24 hours. Griddles filled with water were placed in the humid chamber, and vessels with sulphuric acid and calcium chloride—in the dry chamber. A pulverizer with current of air from a water-pump worked continuously in the humid chamber. Air was drawn into the dry chamber through sulphuric acid. The temperature was equalized by means of an electric heater. The air was of the same temperature in both chambers. The experiments with the aqueous cultures were performed in 3-l vessels and repeated 5 times. The plants were not brought to full maturity, but were removed in full blossom. The sunflower was sown in Prianishnikov's nutrient mixture to which ammonium and nitrate nitrogen were added in a ratio of 1 : 8, in order that the reaction of the nutrient solution should not alter greatly during the vegetation period. During the vegetation period the solutions were changed 5 times. The plants developed quite well and vigorously. The nutrient solutions were aired for 10 min. twice a day. The openings of the vessels were covered tightly with discs. In doing this we were careful to avoid a rise in transpiration as a result of the water evaporation from the vessels instead of through the plants. The quantity of solution in the vessels was kept at definite level, to which they were raised by adding water during the vegetation period. At high relative air humidity the sunflower transpired 32 800 cm^3 and at low humidity 42 300 cm^3. The results—the yield data and the ash composition—are given in the table.

The relative humidity of the air had considerable influence on the growth of the overground mass—leaves and stems, increasing the yield at high humidity and decreasing it at low humidity.

The yield of the root mass at high air humidity was greater than at low humidity. The absolute ash content of the sunflower cultivated at low air humidity is considerably higher than at high humidity. The total quantity of calcium absorbed by the plants at various humidities also varied greatly: at high humidity less of it was absorbed than at low humidity; in the vege-

tative organs there is also a pronounced difference in the content of calcium absorbed by the plant during the vegetation period.

The same relation to the air humidity is observed in the absorption of phosphorus as in the case of calcium. The calcium content per 1 g dry substance of the sunflower is also inversely proportional to the relative air humidity.

If we calculate the quantity of nutrient elements bound by the plants at high and low humidity per liter transpired water, we can quite definitely draw the following conclusion from the material obtained: at low air humidity

Influence of the Air Humidity on the Uptake of Nutrient Elements in the Sunflower

Parts of the plant	Whole plant		Overground part		Roots	
	low relative humidity	high relative humidity	low relative humidity	high relative humidity	low relative humidity	high relative humidity
Yield of dry mass	65.4	70.4	56.1	58.4	9.3	12.1
Water transpired (cm^3) . . .	42300	32800	—	—	—	—
Ash in g	9.9575	8.3754	7.0219	6.6876	2.0356	1.7378
Ca in mg	1.3565	1.2578	1.1000	1.0641	0.2665	0.1937
K in mg	5.6548	5.2795	5.0759	4.7447	0.5789	0.5348
P in mg	0.558	0.5236	0.4629	0.4360	0.0956	0.0876
Ca per 1 l transpired water	32.0	37.3	26.5	32.0	6.50	5.31
P » » » »	13.2	15.9	10.9	14.6	2.32	2.26
K » » » »	133	160	110	137	22.9	22.8
The plants absorbed (in mg)						
Ca per 1 g dry substance .	20.74	17.84	19.70	18.22	27.58	16.01
P » » » » .	8.54	7.43	8.25	7.46	10.28	7.24
K » » » » .	86.40	74.88	90.48	81.24	62.22	44.20
Distribution of all the Ca in the plant in % . . .	—	—	81.8	78.4	18.9	21.6
Distribution of all the P in the plant in %	—	—	82.0	83.3	17.1	16.7
Distribution of all the K in the plant in % . .	—	—	89.8	89.9	10.2	10.1

the plants absorb less mineral elements per liter transpired water than at high air humidity. A calculation of the absolute quantity of each nutrient element per gram of dry substance also shows that at high humidity the plants consumed much less nutrient elements than at low humidity.

The sunflower consumed phosphoric acid just as economically, no matter what the relative air humidity. Although in some cases there is an insignificant difference in the phosphorus content, it is extremely small in value.

In all cases the plants used up more calcium for the synthesis of 1 g of organic substance at low air humidity. The same should be said about the consumption of calcium at varying air humidities.

Experiments with aqueous cultures on Prianishnikov's nutrient mixture showed that the influence of the relative air humidity on the uptake of nutrient elements by plants and on the water transpiration is as follows:

1. At high transpiration the plants absorbed more nutrient elements: calcium, phosphorus and potassium, but gave a low yield.

2. Taking into account the distribution of mineral elements in plants cultivated at various air humidities, it should be noted that there is a considerably greater increase in the per cent of mineral elements in the overground part than in the roots.

3. As the intensity of water uptake increases, the consumption of mineral substances also increases, and a correlative dependence is observed between the transpiration and the consumption of nutrient elements.

The experiment with the sunflower in soil cultures was run on black-soil in five sets in vessels of 6 kg soil capacity. Each of the plants received 0.3 g per 1 kg soil of the active principle NPK. During the vegetation period they were watered up to 70% of the full moisture capacity of the soil. The surface of the soil was isolated from the surroundings by means of cotton-wool and paraffined gauze; the plants were watered twice a day. In both chambers they developed quite favourably.

In all cases when fertilizer was used, the yield of vegetative mass and sunflower seeds was higher at increased air humidity.

The sunflower in the humid chamber developed much better than in the dry one; in the latter it had a less developed leaf surface with a paler green colour. Since the amounts of water supplied to the plants during the vegetation period were estimated by weight, it was possible, after the crop had been harvested, to calculate the transpiration coefficients for plants which had grown at various relative air humidities and had been fertilized variously.

From these data we see that if plants are cultivated in a humid atmosphere, the transpiration coefficient decreases; in the control case, in which the plants did not receive mineral nourishment as fertilizer, they transpired considerably less water at increased relative air humidity than at low humidity.

Similarly, the transpiration coefficient rises considerably at low air humidity, if phosphate and potassium are introduced.

In the case where the plants received nitro-potassium fertilizers, the transpiration coefficient was lower than in the case of phosphate and potassium fertilizer, because both elements (nitrogen and potassium) were in the soil in sufficient quantity. In cases where the plants received nitrogen and phosphorus, they transpired considerably less water in both chambers (the dry and the humid) than in the control and the previous cases.

Finally, in the cases where the plants were fully fertilized, the transpiration coefficient was higher in the dry chamber than in the humid one, but in this case the plants consumed comparatively little water, owing to the fact that the soil had in it sufficient quantity of nutrient elements.

Measuring the leaf surface of the plants grown at various air humidities and also with varying mineral nourishment, we observed a great increase in the size of the leaf surface of the sunflower which had grown in the humid chamber; this was especially well defined when nitrogen fertilizers were introduced and also when fully fertilized. In the dry chamber the surface of the sunflower leaf was considerably smaller in size. The introduction of mineral fertilizers could not increase the area of the leaf surface to the same size as had the plants developed at increased relative air humidity. Mineral nourishment displayed considerable influence on the yield of the sunflower crop, but along with this the humidity of the air also affected the magnitude of vegetation mass and seeds.

In examining the yield of vegetative mass and seeds, we see that the control plants in the dry chamber gave a smaller yield than in the humid one. When phosphorus and potassium were introduced into the soil, the yield of the seeds and vegetation mass in the dry chamber was quite close to the data obtained in the humid chamber. When nitrogen and potassium were introduced, the yield in the humid chamber was considerably higher than

in the dry one, since the nitrogen promoted the forcing out of the vegetative mass, and having a large assimilation surface the plants developed intensely and gave a higher yield than in the dry chamber, where the conditions for the development of the vegetative mass were less favourable. When nitrogen and phosphorus were introduced, the sunflower yield obtained in the humid chamber was considerably higher than in the dry one. This is due to the fact that nitrogen is especially effective at increased air humidity. Although phosphorus promotes the economical use of water by the plants, and nitrogen, on the contrary, increases its expenditure, nevertheless the yield obtained in the dry chamber was considerably less than in the humid one. This is due to the fact that under the conditions of the negative experiment the size of the crop is determined mainly by the quantity of nitrogen accessible to the plant. When fully fertilized, the yield in the humid chamber was also higher than in the dry one.

Below we give the results of an analysis of sunflowers grown in the humid and dry chambers.

The overground part and the root mass of the plants were analyzed. The total ash content in the whole sunflower at low humidity was more than at high humidity. In studying the composition of the ash of the overground part of the sunflower grown at high and low air humidity, we see that at low relative air humidity it absorbed more calcium than at high humidity.

Approximately the same ratio in the calcium absorption of the plants is observed in the roots for both gradations of air humidity. Under all conditions the sunflower absorbed less phosphoric acid than calcium. In the whole plant and in the stems as well the sunflower absorbed more phosphorus at decreased air humidity than at increased humidity. The plants also absorbed more potassium at low humidity than at high humidity. This refers to the whole plant as well as to its separate organs.

We have already mentioned that of the ash elements the sunflower absorbs mostly potassium, less calcium and least of all phosphoric acid. It absorbed very large quantities of nitrogen, more than anything else, except potassium. As a rule, in all cases and in all its organs the sunflower absorbed more nitrogen at low air humidity than at high humidity. Taking into account the quantity of water transpired by the plants during the vegetation period and calculating in milligrams of calcium absorbed by the sunflower per liter of water, we see that the plants as a whole absorbed less of this element at high humidity than at low humidity.

Turning to the phosphoric acid and potassium absorbed by the plants per liter of transpired water, it is evident that the plants absorbed less phosphorus at high than at low air humidity. If the quantity of phosphorus, potassium and calcium combined by the plants in synthesizing 1 g of dry substance on the whole for the sunflower is calculated, it may be noted that more of these elements were spent per gram of dry substance of the plant at low than at high air humidity.

From these data the following conclusions can be drawn:

1. In all the fertilizer combinations in which nitrogen was present, the plants gave a larger yield of total and productive mass at increased than at low relative air humidity.

2. Examining the value of the transpiration coefficient for plants at various relative air humidities, it should be noted that it was greater when phosphorus and potassium were introduced into the humid and dry chambers, than when fertilizers were introduced containing nitrogen which lowered the transpiration.

3. The transpiration coefficient decreased in connexion with the increase in the yields of the plants.

4. The humidity of the air greatly influences not only the transpiration of water by the plants, but also the absorption of the nutrient elements, their movement and also the synthesis of organic substances in the plants.

5. Analysis of the plants showed that as the transpiration rises, the uptake of mineral elements increases. At high transpiration the content of mineral substances increases in the leaves and in the roots.

6. At high transpiration in all the experiments the plants had more ash, calcium, phosphorus, potassium and nitrogen than at low transpiration.

7. As the water adsorption rises, the movement of the nutrient elements in the plants increases considerably.

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HYDROBIOLOGY

ON THE ORIGIN OF THE *OSTRACODA* FAUNA OF THE LAKE BAIKAL

By Z. S. BRONSTEIN

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After the publication of my paper on the Baikal *Ostracoda* fauna (1) I have found in samples from this lake new species and varieties of ostracods, descriptions of which are now being prepared or ready for publication. A total of 36 forms have been described by me. No doubt this is not yet the limit of the specific composition of the Baikal *Ostracoda*. But how ever wide our knowledge of the shell crabs from this lake may extend in the future, we can hardly expect any essential changes to affect the conclusions that can be drawn now on the basis of the fauna already known to us.

The 36 forms described by me are listed under but 3 genera, of which 2—*Pseudocandona** and *Candona* belong to the subfamily *Candonidae*, family *Cypridae*, and the genus *Cytherissa* to the family *Cytheridae*. The *Candoninae* include but one purely marine genus *Paracypris* with a very small number of species, while all other representatives of this subfamily inhabit only fresh-water basins, or in a far less degree belong to euryhaline, and more rarely to halophile species.

I have reported 8 species of the genus *Pseudocandona* for the lake Baikal. Outside of Baikal 3 more ostracods are known from other basins, which I am likewise referring to this genus, namely: *Pseudocandona* (*Candona*) *zschokkei* Wolf., *P.* (*Candona*) *insculpta* J. W. Müller and *P. elongata* Holmes. *P. zschokkei* is known only from subterranean basins of Switzerland. *P. insculpta* lives in small open basins and is rather widely spread in Europe, but rarely met with. *P. elongata* was reported by Holmes from one of the lakes of England and the Okhrida lake (2).

It is very likely (yet not quite sure, for males are unknown) that *Candona marengoensis* and *C. jeanneli* reported by Klie (2) from cave basins of USA, and *C. trigonella* (3) from an identical basin of Yugoslavia, belong likewise in the genus *Pseudocandona*. The former two species show a shell fairly similar in form, a well developed reticular sculpture on the surface of the valves and have the last joint of their sensory legs undivided.

Note should also be taken that in these American species the shell is pigmented. Among non-swimming *Cyprinae***, however, the pigmentation of the

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* *Pseudocandona* Kaufmann (1900)=*Metacandona nini* (1930). Kaufmann gave no comprehensive diagnosis for the genus, and therefore it has not been so far recognized by any other author. However, the only species referred to it by Kaufmann (*Candona insculpta* J. W. Müll.) should, as indicated hereafter, be classed in one genus with my Baikal *Metacandona*.

** The subfamily *Candoninae* falls into two branches standing wide apart from each other. To one of them belong ostracods with second antennae bearing swimming setae, to the other one—those bearing none.

shell is so far known but in one of the Baikal *Pseudocandona* and in *Candona inaequivalvis* v. *baicalensis*.

In *Candona trigonella* the shell is not pigmented and sculptured, but possesses another character peculiar to the Baikal *Candoninae*—the left valve extends considerably over the right one on the dorsal side. Like in the two preceding species, the females of *C. trigonella* too are lacking genital appendages and the penultimate joint of the sensory legs is not divided.

Representatives of the Baikal *Pseudocandona* have a number of characters testifying as a whole to their most primitive organization as compared with representatives of the rest of non-swimming genera of this subfamily. Such characters are referred by me to the heavy, sculptured shell, as well as its trapezoidal form, unusual for other *Candonina*, the undivided penultimate joint of the second antennae in males and the want of sexual setae on it, the undivided penultimate joint of the sensory legs and the absence or but feeble differentiation of genital appendage in the genital region of the body of females (only *Pseudocandona werestschagini* bear genital appendages).

No description of *P. elongata* Holmes has yet come under my notice. As to the two other non-Baikal *Pseudocandona*, they are distinguished by the possession of secondary characters: *P. zschokkei*, which possesses all morphological anatomical peculiarities typical of *Pseudocandonidae*, including also the well developed sculpture of valves, has a divided penultimate joint of the sensory legs, whereas *P. insculpta*, though having an undivided penultimate joint of the sensory legs, displays a rudimentary sculpture of the shell.

The genus *Candona* comprises about 27% of all of our continental *Ostracoda*, regardless of whether the 10 species described by me from the lake Baikal are taken into account or not.

Representatives of this genus are particularly characteristic of the lacustrine fauna. However, the Baikal *Candona* bear such characters as are placing them in a rather isolated position in relation to non-Baikal *Candona*. The characters concerned include, in my estimation, the trapezoidal form of the shell in *Candona rupestris* and *C. dorsoconcava*, similar to the one which is common in *Pseudocandona*, the presence on the shell of some species not only of rudimentary but of well developed reticular sculpture * (*C. dorsoconcava*), occurring in the latter much more frequently than among other *Candona*, the undivided penultimate joint of the sensory legs, the females frequently lacking, or showing feeble development of the genital appendages, though the great majority of Arctic, Siberian and Mongolian *Candona* exhibit strongly developed ones.

Besides, a number of the Baikal *Candona* are characterized first by asymmetry of the valves: the left valve extends considerably over the right one along the entire dorsal margin (*C. dorsoconcava*, *C. inaequivalvis* v. *baicalensis*, *C. semilunaris*, *C. sensibilis*) and, secondly, by the highly specialized first antennae which on the two last joints bear claws instead of the ordinary setae, these claws being at least as powerful as those on the second antennae (*C. depressa*, *C. directa*, *C. unguiculeta*).

According to characters indicated above, nearest to the Baikal *Candona* comes *C. ohridae* Holmes with its shell having nearly parallel dorsal and ventral margins, the left valve overlapping the right one along the whole length of the dorsal margin, the middle portion of the valves having rudimentary

* The reticular sculpture observed in non-Baikal *Candona* has been reported in *C. angulata*; however, it has been indicated also as present in larvae of some species while lacking in adult forms.

sculpture, genital appendages not differentiated. However, in this Baikal *Candona* the penultimate joint is divided.

First antennae armed with claws are unknown in all the other *Cypridae*. The above-mentioned specialization of the first antennae is commonly believed to be quite in agreement with the characters of primitive organization.

However, the peculiar asymmetrical arrangement of the valves is so far apt to be regarded as a proof of close genetic relationship between the above-mentioned forms inter se and with some of the *Pseudocandona* possessing the same characters (*P. gajevskajae* and *P. sextilis*).

Thus, we see that in the Baikal *Candona*, as compared with *Candona* from other basins, there have persisted characters of primitive organization, pointing to their more ancient origin.

Genus *Cytherissa* is one of numerous genera of the family *Cytheridae*, whose representatives are for the most part of the pure marine type, but few of them dwelling in brackish waters and to a still less extent in fresh-water basins. I have described 18 species and varieties of the genus *Cytherissa* for the lake Baikal. For other basins only one species *Cytherissa lacustris* G. O. Sars is known, dwelling in large fresh-water lakes of Eurasia and Japan. *C. lacustris* reproduces only parthenogenetically, while for all non-Baikal *Cytherissa* males are known. There is no doubt that the amphigony of the Baikal *Cytherissa* is a more ancient character as compared to the parthenogenesis of *C. lacustris*.

Only one of the Baikal *Ostracoda—Candona inaequivalvis* var. *baicalensis*—even though not inhabiting any other basins, still stands near to the non-Baikal species. The typical form *Candona inaequivalvis* was described by Sars according to materials from basins in the vicinity of Verkhoyansk. The remaining 35 Baikal *Ostracoda* seem to be endemic for this lake. I have arrived at this conclusion on the basis of our knowledge of *Ostracoda* of Eurasia, the latter fauna having already been extensively studied, and on the basis of information, thus far inadequate, on the fauna of basins lying nearest to the Baikal, as well as from lake Kosogol, a basin connected with the Baikal by its origin and also by the fact that nearly as low temperatures are prevailing there.

Only two *Ostracoda* are known from the lake Kosogol: two species of *Candona*, both described by Dadai (*C. elpatievskii* and *C. tuberculata*). But it is hard to believe that no other representatives of *Ostracoda* should occur in this lake. Still they may be used as material for comparison. *C. elpatievskii* and *C. tuberculata* possess shells which are common for the genus, except for the tubercles on the shell of one of them, the strongly developed genital appendages in females and the divided penultimate joints of the sensory legs. Thus, these two species are to be referred to the phylogenetically younger group of species *Candona*, not peculiar to the Baikal. Besides, I have every reason to suspect that *C. elpatievskii* is at least no more than a variety of *C. caucasica* described by me for the lake Sevan, if it is not identical with this form.

On behalf of the Baikal Lymnological Station of the Academy of Sciences I had recently to treat the collections from the basins of the Tunkin valley. I identified among them 8 species, including 5 holarctic ones and 3 widely spread in the Palearctic regions. The B. Koty Biological Station of the Irkutsk University has sent me one sample taken not from the lake but on the lake shore, from small pits fed by a cold spring. This sample contained *Eucypris pigra* Fischer, known not only from shallow basins, but from lakes as well, for instance, the lake Teletzky. In the Baikal this species does not occur.

The implication of the above facts is that at the present time, owing to the Baikal *Ostracoda*, not the geographical but only the ecological isolation of Baikal may be spoken of. It will therefore be apparent that the knowledge of these factors is essential for the explanation of the endemism of the Baikal *Ostracoda*.

By the number of endemic *Ostracoda* Baikal is likely to stand comparison even with the lake Tanganyika. For the lake Tanganyika Sars described 82 species, and only one of them has been found to dwell in another basin as well (lake Nyassa). Like in the Baikal, *Ostracoda* of the Tanganyika belong to a limited number of genera (4 genera), none of them being endemic to this lake. However, the similarity between ostracods of these two remarkable lakes is exhausted with this fact. Their faunal composition is entirely different. Though 2 genera of lake Tanganyika *Cypridopsis* and *Ilyocypris* are common for other lakes, no representatives of them have as yet been discovered in the lake Baikal.

The question as to whether ostracods of the Baikal are relicts of the Tertiary fresh-water fauna should be treated by using paleontological material as well.

In April of 1937 A. V. Schwejer wrote me that he had established for the fossil *Ostracoda* the genus *Alexandrella*, but afterwards, having read my description of the hinge in the Baikal *Cytherissa*, he became aware of the identity of the genus *Alexandrella* with the genus *Cytherissa*, previously described by Sars. In his letter Schwejer points out that he used to find *Cytherissa napthotscholana* (Liventhal) in prodigious numbers in Tertiary deposits of USSR. Upon my request Schwejer has kindly sent me a few excellently preserved valves of *Cytherissa napthotscholana* (Liventhal)-*Baerdia napthotscholana* (Liventhal) and *Cytherissa* (*Cythera*) *bogatschovi* (Liventhal) v. *elongata* Schwejer.

The examination of these valves has shown that not only is their hinge typical of the genus, but so are also their pore channels. V. E. Liventhal [5] has found *Cytherissa napthotscholana* both in the deposits of the Akchagyl and the Apsheron stage, while *C. bogatschovi* occurs only in the latter deposits.

It will be obvious that the representatives of the modern genus were occupied already in the Pliocene as mass forms, and that this genus in its origin is linked to brackish-water basins.

An important point in the line of evidence for the relict character of the Baikal *Cytherissa* would be the amphigony of the species inhabiting this lake. In the case of *C. napthotscholana* and *C. bogatschovi* this seems to be established beyond any doubt.

Thus, the shells which are identified by A. V. Schwejer on the basis of their more convex form as belonging to a special variety *elongata*, must have really belonged to males *Cytherissa napthotscholana*, as shells of males *Cytherissa* in relation to shells of females are invariably «*elongata*». For the same reason it may be argued that Liventhal's plate 26 (Table 11) represents the valve of the male shell *Cytherissa napthotscholana*, while plates 22 and 23 represent valves of female specimens.

In addition to the genus *Cytherissa*, the Pliocene deposits of USSR have been known to carry the genera *Candona*, *Limnicythera* and *Cyprideis* (whose all species are likewise non-swimming), peculiar to the contemporary fauna of fresh- and brackish-water lakes as well.

Liventhal has described 5 species of the genus *Candona* for the Akchagyl stage. That they belong to this genus is convincingly proved by the figures presented by him. In their outlines these shells recall the contemporary non-Baikal *Candona* more than *Candona* and the allied *Pseudocandona* from Baikal. However, a closer examination of the shells of the 4 species has shown that

they possess primitive characters of the Baikal forms, however, not as sharply expressed. Thus, in *C. pseudocandida*, *C. abichi* and *C. convexa* the left valve of the shell is overlapping the right one along the whole length of the dorsal margin, and in *C. abichi*, moreover, the dorsal and ventral edges are parallel, like in *C. directa* from the Baikal. Finally, in *C. gracilis* the valves of the shells bear a well-marked sculpture on their surface, which is similar to that known in *Pseudocandona zschokkei* Wolf. Considering those characters of shells in the above-mentioned Pliocene *Candona* which are intermediate between *Candona* and their close allies *Archicandona* from the Baikal, on the one hand, and the contemporary *Candona* from other water basins, on the other, I have arrived at the conclusion that the Baikal forms of the two genera took their origin in earlier times than the Pliocene.

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DEVELOPMENT MECHANICS

EFFECT OF THYROIDECTOMY ON *PICA PICA* L., A REPRESENTATIVE OF THE NESTLING GROUP

By A. A. WOITKEWITSCH and J. A. WASSILIEV

(Communicated by L. A. Orbeli, Member of the Academy, 14. VII. 1939)

In a previous communication the authors have described the development and behaviour of young rooks and starlings after extirpation of the thyroid glands([1]). Now we should like to set forth, in a preliminary way, the results of experiments on other thyroidectomized representatives of the nestling group, namely, magpies (*Pica pica* L.). The object of the present work, in which the development and behaviour of young birds were studied with reference to their dependence on hormones, was also to investigate the relation between the behaviour and the thyroid apparatus in adult birds of the nestling group. Such an investigation was already previously declared to be necessary. At the same time the material under investigation was used for tracing the changes due to athyreosis in the process of feather-formation.

As material for observation we have used: 1 young and 3 adult thyroidectomized magpies, which have lived long after the operation. It is a relatively meagre material of course and our conclusions therefore are to be regarded as preliminary. True enough, our predecessors ([3],[4],[5]) worked on material which was more accessible and convenient for operation (domestic geese and chickens), but then only single specimens among this material had their thyroid glands completely removed. When experiments are performed on wild forms, the difficulties connected with the operation and post-operative care of the birds are greatly enhanced. Incidental changes in the conditions of upkeep may cause heavy losses among thyroidectomized birds. Let us reiterate that out of a total of 36 operated young rooks 34 perished within 100 days after operation. On the other hand, control birds of the same age kept under identical conditions were perfectly well. Among various kinds of adult thyroidectomized birds (rooks, jackdaws, crows, magpies) only magpies as yet were brought to live long enough after the operation to make regular observations possible. On this occasion it may also be noted that experiments similar to ours do not always require the use of a great amount of material. When individual daily records of the reflex activity are taken, an excessive number of experimental birds interferes with regular work. These few remarks may serve to estimate the results reported in the proper light.

The technique of the extirpation of thyroid glands being described previously([2]), let us proceed directly to the results of the observations. Just a few words about the results of experiments on young magpies. The young of a

brood were taken from the nest when the vanes of their remiges were nearly half of their ultimate size. A day later one bird was operated on. Observations on the development of this magpie have demonstrated its similarity to that of thyroidectomized rooks. Retarded growth and development of the plumage as compared to control birds was not as sharp as that displayed by rooks, inasmuch as the operation was performed at a relatively advanced age*. The operation produced the strongest effect on the development of steering feathers which have developed in the thyroidectomized bird, as compared to the control one, rather slowly: with considerable delay the tail attained the length of 13 cm, whereas in the control bird it exceeded 20 cm. At the time when the control bird took to the wing, the thyroidectomized magpie was unable to fly off; neither could it fly afterwards. The operated bird was less mobile, less responsive to sounds stimuli, it retained the altricial type of behaviour; for instance, it flapped the wings at feeding allowing the food to be put into its mouth instead of snatching it from the hands, the way non-operated magpies do. The control birds differed little in their behaviour from adult magpies: uttering cries (chirping) typical of the latter.

Fig. 1. Left—thyroidectomized magpie (photo taken 12 months after operation), right—normal magpie of the same age.

Adult magpies were thyroidectomized at the age of one year, just when the natural moult was beginning. Birds which were taken from the nest a year ago were brought up in the laboratory, where they have developed food reflexes to sound stimuli: experimental magpies (thyroidectomized later on) responded to the metronome, ordinary whistle and word «dva» (two); and the control ones, to the word «tri» (three) and «peak». The observations which continued for 14 months after the operation were dealing principally with the behaviour and the condition of plumage in the birds concerned.

Prior to the operation all birds exhibited normally developed plumage. When about to be operated on, the experimental and control birds shed two primaries on each wing.

Results of periodical counts of new-growing feathers replacing those shed warrant the conclusion that the moult which had begun prior, stopped immediately after the operation. Twenty days later it renewed proceeding further with less intensity than in control birds. Consequently, the moulting of magpies came later to an end in the experiment than in control. A year later the thyroidectomized magpies did not moult altogether, whereas the control ones as well as a thyroidectomized magpie given thyroidine passed the normal cycle of moulting. In thyroidectomized birds the new plumage differed greatly from that of the normal bird. Groups of small feathers were not sufficiently developed: the pteryliae of the head, neck, body, foot and wings were hardly if at all covered with feathers, large spaces entirely destitute of feathers were not infrequent (Fig. 1). The size, shape and structure of feathers of all series in thyroidectomized birds deviated sharply from the norm. The vanes of the feathers were shorter and narrower, with tapering ends (Fig. 2). The downy part was either partly or entirely suppressed. The remiges and rectrices exhibited relatively less variations. Feathers which in

* Magpies thyroidectomized at an earlier age perished prior to the completion of their development.

normals were bi-coloured—black and white, were in operated birds either entirely lacking melanin (the basal part of the vane in the body feathers), or the latter was retained in the upper parts of the feathers (primaries). In thyroidectomized magpies all pigmented feathers, irrespective of their ar-

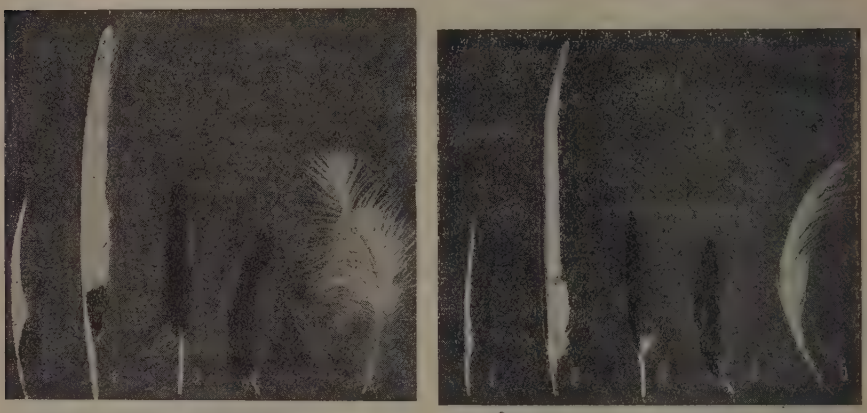

Fig. 2. Feathers of normal (left series, $\times^1/_2$) and thyroidectomized magpie (right series, $\times^2/_3$). *1*—primary № 1, *2*—primary № 2, *3*—covert of primaries, *4*—covert of secondaries, *5*—feather from ventral pteryliae (flank). Half size.

rangement, showed a loss of melanin in the basal part of the vane. The feathers of the experimental birds were less elastic and broke easily, and for this reason the rectrices, which are so characteristic of the plumage of normal birds, were altogether lacking in the birds under experiment. Differences

Fig. 3. Structure of barbs of feathers from the black hood of the normal (left) and thyroidectomized magpie (right). x 45.

were observed also when studying the structure of the vane. They are less marked in the ore- and steering-feathers, but then the feathers of the body, head and neck show essential deviations of structure. This is obvious from the adjoined photomicrograph where corresponding regions of the vane in a normal and a thyroidectomized magpie are available for comparison. The number per unit area of primary and secondary barbs is seen to be considerably smaller in the latter than in the former. The secondary barbs are shorter, less elastic and irregularly arranged about the secondary barbs of the neigh-

bouring radius. No hooklets, which are fastening the secondary barbs in the vane of the normal feather. With the introduction into thyroidectomized birds of the thyroid gland hormone (in sufficient concentration) the development of new feathers of normal shape, structure and colouring is furthered.

All the above-mentioned peculiarities in the structure of feathers after thyroidectomy may serve as an explanation, why after moulting experimental birds lose their power of flight. However, they retain their former mobility, restlesseness and typical twitch of the caudal part of the rump, notwithstanding the absence of the tail. They hop well on the floor and upon the perches of the cage. In respect to the general behaviour and previously acquired conditioned food reflexes we failed to reveal any difference in the experimental birds between the pre- and post-operative period, as well as on comparing them with the control ones. Only one of the operated birds became shy immediately upon the operation and sat on the perch without reacting to the whistle; later on this inhibition stopped and the former reaction reappeared fully. The reaction to sound stimuli acquired before the operation continues after the operation as well. In one of the thyroidectomized magpies (responding to the word «dva») we succeeded without difficulty to call forth a rotation reaction to the sound stimulus, typical of normal jackdaws and rooks.

The experiments described in the present work lead to the following conclusions. The removal of the thyroid gland in a young magpie causes, along with a certain inhibition of growth, a retardation of the plumage which had started developing before the operation. In adult birds the moult is inhibited when coinciding in time with thyroidectomy; a year later it does not occur at all. Feathers grown after the first moult appear by a number of characters to be underdeveloped. Consequently, the feather will not develop normally unless the thyroid gland hormone is present in the organism of the bird. The indispensable nature of this hormone for the feather-formation is substantiated by the regeneration of normal feathers after artificial thyroidization of the thyroidectomized birds. The extirpation of thyroid gland in a young bird inhibits the development of a definite type of behaviour, whereas in adult birds the lack of the thyroid hormone does not produce any marked effect upon the formerly acquired complex of reflexes.

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PALEONTOLOGY

IMPRESSION OF *HAUSMANNIA* FROM PALEOGENE DEPOSITS OF MOGILNO, WESTERN UKRAINE

By N. V. PIMENOVA

(Communicated by A. A. Borissiak, Member of the Academy, 13. VI. 1939)

In the course of further revision of materials on the Paleogene flora from the West-of-Dnieper Ukraine, formerly described by the author(1), especially upon acquaintance with the work by A. Hollick(2) obtained afterwards, I could not but arrive at the conclusion that the genus of the fern *Hausmannia* characteristic of the Mesozoic (up to the Lower Cretaceous) had apparently not become extinct during that time, but persisted into the beginning of the Tertiary, at least on the territories of Ukraine and Alaska, remote as they are from each other. The occurrence in both the former and the latter of this very archaic genus undoubtedly points to the ancient relationship of the floras characterized by him, and probably to the more ancient Tertiary age of the corresponding sandstones of Ukraine than has been generally claimed. Paradoxical as may seem the occurrence of the fern *Hausmannia* in association with the unquestionably Tertiary flora, there is no sufficient ground to doubt the validity of the definition. However, it would be of course desirable to obtain more complete paleontological material, with leaves, possibly, bearing sporangia which would testify unmistakably to the kinship of the described object with ferns.

Fig. 1. *Hausmannia enigmatica* Pimenova sp. n. Impression of part of the leaf blade with sharply marked veins, on sandstone, from Mogilno. Nat. size.

Hollick's work(2) on the Tertiary flora of Alaska contains a description and picture of the fern *Hausmannia Atwoodii* Hollick (p. 36, table VI, Figs. 6—9).

On comparison it became evident that pictures shown by Hollick strongly suggest the impressions which I depicted[(1), p. 21, Table VII, Figs. 1—2]

under the name of *Nelumbium* sp.(?), pointing out at the same time that the venation of the leaf is very much like that in *Hausmannia*. The impression shown by me (l. c.) exhibits part of a large rounded leaf, from the mid vein of which are radially diverging veins repeatedly dichotomizing (branching 4—5 times) and with pronounced secondary veins directed toward them at angles of 90°, or approaching 90°. The anastomoses form a distinct and sharply marked net-work of squares, a feature very distinctive already of *Clathropteris* and persisting in *Hausmannia* as well. The leaf margin in the impression from Mogilno is serrate. A certain resemblance of these characters to those in *Nelumbium* leaves has induced us to draw a comparison between them. The serration of the margin is, however, not common for the type *Nymphaea*

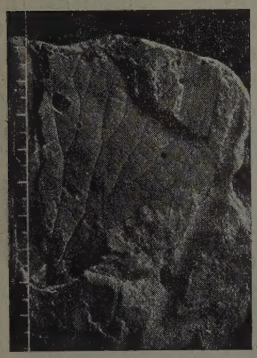

Fig. 2. Impression of part of leaf blade pertaining to a smaller leaf, from the same locality with characters of marginal indentation (right). Nat. size.

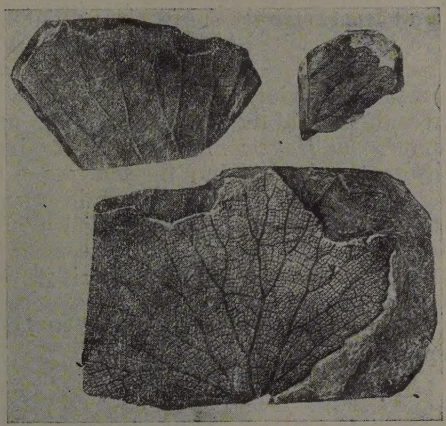

Fig. 3. *Hausmannia Atwoodii* Hollick. Impressions of parts of leaf blades from Alaska, after Hollick. Nat. size.

Nelumbium, though the leaves of *Nymphaea* have sometimes clearly toothed edges. However, the serration observed bears much more likeness to that often indicated for a number of species of the fern *Hausmannia*. But owing to the obviously Tertiary composition of the Mogilno flora, it would not be reasonable to admit here the persistence into Eocene, or even Oligocene, of the fern *Hausmannia* which is generally even more characteristic of the more ancient Mesozoic than Lower Cretaceous.

However, from my acquaintance with the work by Hollick on the Tertiary flora of Alaska, i. e. after the description of the Tertiary flora from the West-of-Dnieper Ukraine had been published, it became for me perfectly clear that the resemblance between the Ukrainian and Alaskan impressions is rather close if not complete. Consequently, if the impression *H. Atwoodii* from Alaska really represents this fern, then the leaf from Mogilno belongs to none but this generic type.

It should be noted in general that there is a very strong resemblance between our Paleogene impression and similar Mesozoic forms. Thus, for instance, the venation in *Protorhypis Buchii* Andrae([3]) is a perfect reproduction of the one in our leaf from Mogilno. Imprints of the Jurassic *Hausmannia* from V. D. Prinada's collections of fossil flora from Siberia, likewise resemble very much the impressions from Mogilno. The imprint of the leaf *Hausmannia ussuriensis* Krysht. from the Upper Triassic (Mongugay) deposits of the western coast of the Amur bay of the Primorskaya province is

distinguished by smaller size, the venation being very much alike (4). A rather similar impression, like *H.* aff. *Buchii* Andrae, is shown by A. Carpantier(5) from the Lower Cretaceous flora of Feron-Glageon (p. 25, Table III, Fig. 2, 2bis).

A. N. Krishtofovich turned my attention to the striking resemblance of the impression, described under the name of *Nelumbium* (?), with *Hausmannia*, but the occurrence in Paleogene deposits of such a purely Mesozoic form seemed to me then quite improbable.

However, repeated studies of impression and literature have shown that we are actually dealing here with an impression of *Hausmannia* which was nominated after the author *H. enigmatica* Pimenova sp. n.

In Mogilno *Hausmannia* occurs in association with evergreen tropical, or, at least, strictly subtropical plants, whereas in Alaska it has been found in company with Arctico-Tertiary or Turgai flora, alongside of *Osmunda*, *Trochodendroides arctica*, *Comptonia cuspidata*. At the same time in the nearest and evidently coeval deposits of the Herendeen bay still other representatives of the same Turgai flora occur. This evidence of different environment of *Hausmannia* in the Ukraine and Alaska is easily explained by different latitudes, but the fact alone of the survival of *Hausmannia* from the Mesozoic into the Paleogene is extremely interesting, pointing, possibly, to the very old age of the so-called «Poltavian» flora from Volynia. The Tertiary flora of Alaska including *Hausmannia*, limited as its composition appears, not infrequently carries in its midst remains of very ancient types (*Cycadophyta*) ascending up to the Paleocene (Paskapoo-Fort-Union), which in North America retains a number of features in common with the flora of Upper Cretaceous.

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